SOIL SURVEY
of SASKATCHEWAN

COVERING THE
AGRICULTURALLY SETTLED AREAS
NORTH OF TOWNSHIP 48

BY

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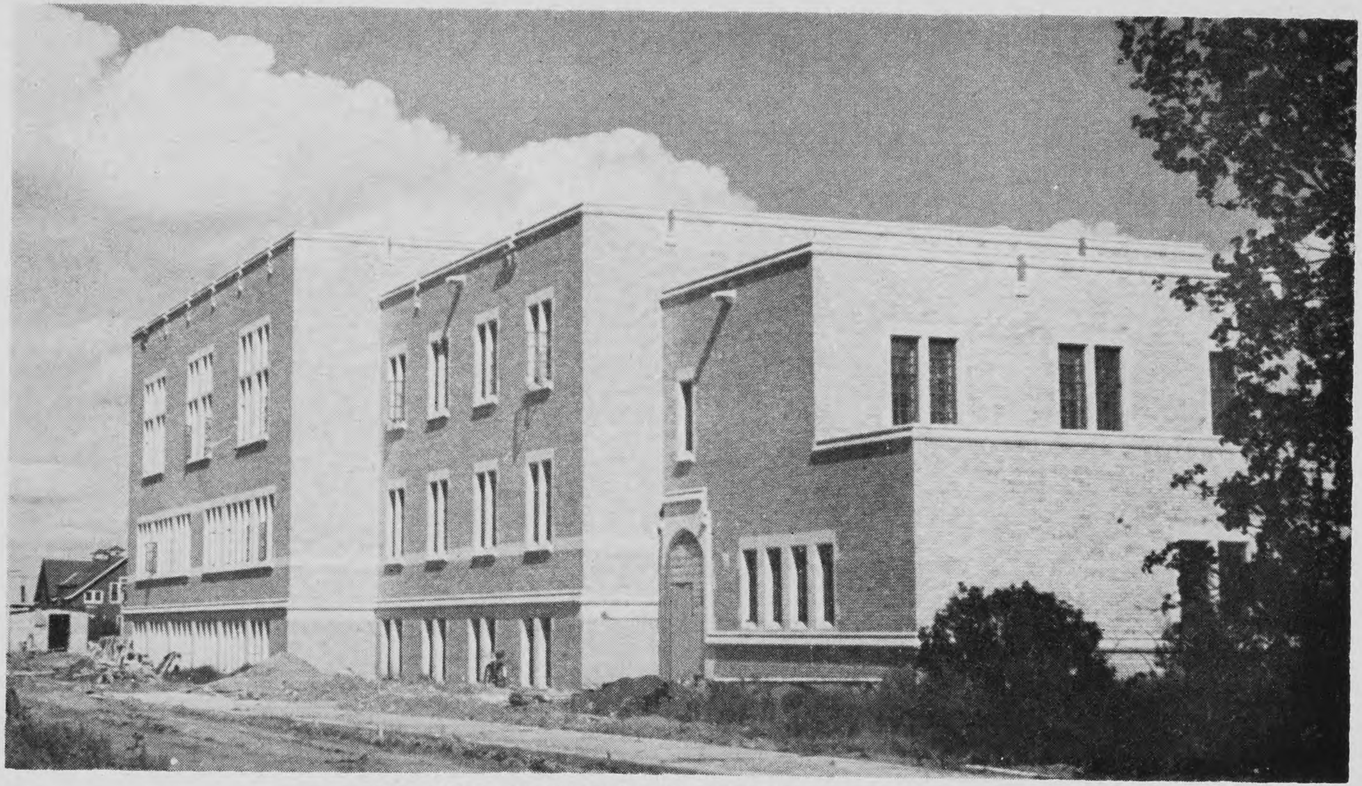
UNIVERSITY OF SASKATCHEWAN
IN CO-OPERATION WITH
DIVISION OF FIELD HUSBANDRY AND SOILS
EXPERIMENTAL FARMS SERVICE, OTTAWA
AND
DEPARTMENT OF AGRICULTURE, REGINA

SASKATCHEWAN SOIL SURVEY
REPORT No. 13
1950



SOILS AND DAIRY BUILDING, UNIVERSITY OF SASKATCHEWAN
Headquarters of the Saskatchewan Soil Survey

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Final drafting of the maps for publication was undertaken by the Division of Field Husbandry and Soils, Experimental Farms Service, Ottawa.

Much useful information dealing with the subject matter of the Report was obtained from farmers of the area, from officials of rural municipalities, from personnel of the Dominion and Provincial Departments of Agriculture, and from members of the field staff of the Saskatchewan Assessment Commission.

Lastly, we wish to acknowledge helpful advice and criticism obtained from colleagues at the University of Saskatchewan.

Preface

THIS publication is the thirteenth in a series of Soil Survey Reports issued by the Department of Soils, University of Saskatchewan. Taken together with Soil Survey Report No. 12, which covers the southern portion of the Province up to and including Township 48, Report No. 13 extends the reconnaissance soil survey over the entire agriculturally settled area.

Soil survey work in Saskatchewan was begun in 1921. The first soil report, covering an area in the vicinity of Moose Jaw, was published in 1923. The project was, from its commencement, an activity of the Department of Soils, University of Saskatchewan, and responsibility for the direction of the Soil Survey remains in that department.

It is of interest that the Soil Survey was begun as a result of a recommendation made by a Royal Commission of Inquiry into Farming Conditions, appointed by the Provincial Government in 1920. The Commission, in turn, was appointed as a result of a resolution passed at a Better Farming Conference held at Swift Current in the same year. The Province, particularly the southwestern area, had passed through several trying years of drought and soil drifting, and no doubt these conditions inspired the Better Farming Conference and the appointment of the Royal Commission which followed. As a result of the recommendations of the Commission, the Soil Survey was commenced in 1921, and since 1929 the Dominion Department of Agriculture, through the Central Experimental Farm, has given assistance to this project.

The Saskatchewan Soil Survey is now a co-operative undertaking involving the Experimental Farms Service, Dominion Department of Agriculture, the Land Utilization Board, Provincial Department of Agriculture, and the Department of Soils, University of Saskatchewan. This co-operative arrangement has tended to broaden the scope of the soil surveys, and also has materially hastened the progress towards a completion of a reconnaissance soil map of the settled area of the Province.

The first purpose of the Soil Survey is to scientifically classify the soils of an area, and to supplement this activity by examining their physical and chemical nature in the laboratory. The results must be organized and placed in maps and reports so that they are usable by anyone interested in the soil.

The assembled information serves as an inventory of the soils of an area, and makes possible the ready correlation of the problems and queries of the farmer with the chief factor affecting his enterprise, that is, the soil.

There are many important uses for the information contained in soil survey publications. In the first place, the information is basic to most soil and agronomic investigations. The land appraiser or assessor finds soil survey data essential in his field of work, and the land seeker finds it a valuable guide in his search for a suitable farm. The soil survey information serves as a basis for considering the problems of land utilization, and as a guide to administrative departments concerned with land and agricultural policies. The soil survey is also of value to the geologist in indicating the character of surface deposits, and to the geographer who is interested in the physical and cultural features of the region.

To the farmer, the Soil Map and Report provide the basis for obtaining information on existing problems of production as related to his particular soil conditions. This knowledge enables him to correlate his own conditions of soil and climate with neighbouring or distant areas. He is thereby better able to adjust his farm practices to meet new problems and to better utilize new agricultural information as it becomes available.

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SOIL SURVEY

of

SASKATCHEWAN

Covering the Agriculturally Settled Areas North of Township 48

By J. MITCHELL, H. C. MOSS, and J. S. CLAYTON*

Introduction

THE publication of this Report and accompanying maps completes the soil survey of the agriculturally settled area of Saskatchewan on a reconnaissance scale. Soil Survey Report No. 12 covered the southern portion of the Province up to Township 48. This Report covers the remainder of the area, including Township 49 and north to the present border of agricultural settlement. Soil Survey Report No. 13 is, therefore, complementary to Soil Survey Report No. 12, and for those who require soil information covering the whole of the settled area of the Province, it will be necessary to make use of both Reports.

As in the soil survey of Southern Saskatchewan (Report No. 12) the field mapping was on a broad scale commonly described as a reconnaissance scale of soil survey. However, the field mapping was done in greater detail in the present report wherever roads would permit. The maps are published on a scale of three miles to one inch instead of six miles to one inch as in Report No. 12. In many places, however, lack of roads, or poor roads, allowed only broad traverses by car, and in such areas, the detail and accuracy of the soil map are lessened.

The publication of Soil Survey Report No. 13 completes a phase in the development of the Saskatchewan Soil Survey. In future, revision of the whole settled area may be undertaken on a more detailed scale of mapping. This is according to the original plan for mapping the soils of Saskatchewan, and in conformity with the recommendation of the Royal Commission which was responsible for the establishment of the soil survey project.

The area covered in this Report is smaller and in some respects quite different than that covered in Soil Survey Report No. 12. Report No. 13 being entirely north of Township 48 includes none of the Dark Brown or Brown soils of the drier prairie area. On the other hand, there is a much larger proportion of Grey Podzolic and Degraded Black soils, and many new associations of such types are accordingly described. Agricultural practices of the area are modified by the fact that Grey Podzolic soils are commonly less fertile than prairie soils, and also because of the generally cooler, moister climatic conditions prevailing throughout the area.

*Members of the Department of Soils and of the Soil Survey staff who assisted in gathering data for this publication include: O. P. Bristol, H. G. Dion, R. A. Gross, W. L. Hutcheon, W. K. Janzen, F. W. Schroer, A. D. Scott, W. A. Van Haerlem, D. Wilkinson.

This publication consists of soil maps and a written report. These are supplementary to one another. Both should be referred to in seeking information about the soils of the area.

The Soil Maps.—The maps accompanying this Report are published in sections of a convenient size. Each section is complete with heading and legend. Land areas may be located by reference to railways, towns, or post offices, but particular parcels are located by reference to section, township, and range. Township and range numbers may be found on each map, and a diagram of a township is included with the legend to illustrate the system used in numbering sections within each township.

Individual soil areas are enclosed by solid black lines, and the kind of soil in an area is identified by the use of colours, letter combinations, and symbols. In the present map an important change has been made in the use of colours. In former maps, the colours were used chiefly to identify the surface texture of the soil. In the present maps the colours are used more to identify the association. This is done by assigning certain colours to soils on glacial till, and other colours to soils on glacial lake deposits and so on. Thus, all shades of blue represent soil associations occurring on glacial till; the different shades are used to separate soils on unsorted morainic till and on resorted till. Other shades separate Grey Podzolic (Grey Wooded) soil on till from Black and Degraded Black types. Finally, it may be noted that the main colours still indicate the textural range of the soil. Thus, the blue colours, indicating soil on till, also imply loamy textured soils—light loam to clay loam. The actual texture and the specific soil association are combined in the letter symbols shown in each soil area. For instance, WhL represents an area of Whitewood soil of predominantly loamy texture. These letter combinations are the most important part of the map legend, since they relate the area in the field to the kind of soil described in the Report. It is, therefore, important to learn to use and interpret the letter combinations, and to read the descriptions of the associations to which they refer. Special map colours and abbreviations are used to indicate poorly drained or "alkali" lands, rough and eroded lands, and other areas not included in established soil associations. Excessive stoniness and the presence of gravelly subsoils are also indicated by appropriate abbreviations.

The topography of an area is an extremely important feature and as such must be shown on the map. The grouping of various types of topography is of necessity made on a somewhat arbitrary basis. The separations made for the purposes of these maps are described in the Report and shown on the map by suitable cartographical methods. All map abbreviations, symbols, colour schemes, conventional signs and systems of indicating topography are listed and illustrated in the map legend.

The maps and the report may be used to assist in evaluating land parcels in the area. They should not be used for such a purpose without personal inspection of the land concerned, since the scale of mapping is not sufficiently detailed to show all local variations which may occur on individual farm units.

The Report.—The Report is divided into suitable sections, and these are listed in the table of contents.

The most important section of the Report is that which describes the various soils shown on the map, and gives their agricultural adaptations. Each soil association is dealt with separately, and the user of the map must turn to the Report for full information on a particular soil. It is obviously impossible to show all information and to give complete descriptions of soil associations on the map itself.

A section dealing with the system by which soils are classified in the field is included in the Report. This section will repay careful study since it will assist the user of the maps to gain an understanding of the reasons for separating areas as shown on the map. With even a slight knowledge of the features used in separating soils, it is easy to follow the more distinctive boundaries between types of soils.

Other sections of the Report deal with the subjects of climate, natural vegetation, physical features and other matters pertinent to an understanding of the nature of the whole area and of the problems incident to agricultural development of the area.

Statistical information is included in the Report to supplement statements given in the text, while illustrations have been provided to show landscapes, land use, cultural developments and natural vegetation of the area. Some reference is also made to the geology of the area and the relationship of geological deposits to soils. Moreover, much of the land in this area is under forest cover so there is some reference to the importance of protecting and improving forest resources.

*Soil and Plant Relationships**

Someone has said that the fabric of human life is woven on earthen looms—it everywhere smells of the clay. It is likely that the pattern of civilization was a very indistinct one until man attained at least the primitive skills of agriculture. He could have little time for contemplation while food had to be hunted. As his fields grew and his flocks multiplied, it was but natural that much of his poetry, as well as his prosperity, should be closely linked to things agricultural. There are many references in the earliest writings to problems of the land, and some show an acute awareness of the need for preserving the fertility of the soil.

Civilization took form in a world even less secure from starvation than is the world of today. Early man was without the facilities of commerce and transportation developed in the last few centuries, so had only limited opportunity to obtain his needs from afar. Furthermore, there was constant danger from raiders, both animal and human, against which he had only limited means of defence. He was at the mercy of insect pests and crop diseases, and his knowledge of the methods of maintaining the productivity of the soil was quite inadequate. Entire civilizations have disappeared in the past due to the failure of the food supply. In the world of today, with its increasing population, the problem of enough food is still a critical one.

*A comprehensive discussion of this subject may be found in "Soil Conditions and Plant Growth" by E. J. Russell, Longmans, Green and Company, and in other standard textbooks on soils.

In the modern world, many human beings live remote from the land which gives them sustenance. This is not a remoteness of distance, but rather a remoteness resulting from lack of interest in, and understanding of, the problems relative to the growth and production of plants and animals. There are many among those who dwell in cities or towns who have only a casual awareness that bread comes from wheat, milk from cows, and that both plant and animal life depend upon the fertility of the soil for growth and reproduction. It follows, therefore, that there is a large section of the population which has, in general, little concern about the land and its conservation, or of the continual need of safeguarding our food supply against insects and disease. Man must eat to live and if he is to continue to eat in ever larger numbers then there must be a greater awareness by all the population that the food supply depends primarily upon the fertility of the soil and the growth of green plants.

That the nature of the soil profoundly affects the growth of plants is common observation. External factors such as sunlight, air, and heat, while essential to growth are, in a degree, beyond the practical control of the agriculturist. On the other hand, the amount of soil moisture and the supply of available nutrient elements are factors capable of modification. Maintenance of fertility, however, is not necessarily synonymous with maintenance of good productivity. The latter depends not only on the fertility of the soil, but also upon the managerial ability of the farmer in selecting suitable crops, sowing good seed, controlling weeds and pests, and on a host of other factors of which no one is more aware than the farmer himself.

Modern science has provided a solution for many of the problems confronting agriculture. It has given an understanding of the nature of the relationship between plant and soil hardly conceived a century ago. Yet there remain many unsolved problems to challenge the investigator, equipped though he is with modern methods for attacking them. Furthermore, new problems continually appear, so that the methods of science must find ever increasing application in the field of agriculture.

Under culture, whether growing wheat, corn, cotton, rice, fruit, vegetables, grass, or trees, the ability of the soil to produce the crop desired by the husbandman determines in a general way the worth of the land. Primarily, it is a matter of the ability of the soil to satisfy man's universal need for food, clothing, and shelter. But abundance of yield is not the only criterion to apply in measuring the worth of the land. The real quality of the product must also be considered. For instance, the nutritive value of a food crop may vary greatly, and the highest yielding fields may not produce crops of the highest quality. With the growing knowledge of nutrition, demand for real quality in foods may be expected to assume far greater significance in the future. The nature of the soil is a factor of vital importance in determining the quality of the crop grown as well as the abundance of yield.

The Nature of Soil.—Some understanding of the nature of soil and the process of plant nutrition is not only necessary to the farmer, but is highly desirable for those who may stop to consider that food must do more for the body than satisfy a present hunger.

The soil is a natural body with characteristics which make it distinct and separate from other natural objects. Mineral soils are mainly composed of mineral material, derived from the weathering of rocks. On the other hand, organic soils such as peats and mucks consist largely of decomposing vegetable matter. Mineral soils are the most important agriculturally, and occupy a far greater proportion of the earth's surface than do organic soils. It is, therefore, appropriate that this discussion should be mainly concerned with the nature of mineral soils.

The soil occupies a relatively thin layer on the surface of the earth. It is formed through natural weathering which becomes effective when hard rocks such as granites or soft mineral deposits like boulder clay are exposed to the elements and to the influence of plant and animal life. The effect of moisture, temperature, atmospheric gases such as oxygen and carbon dioxide, along with the influence of growing plants and burrowing animals produce notable changes in the original mineral material. These effects may extend from a depth of a few inches to several feet, depending upon the nature of the parent material, the intensity of weathering, and length of time such agencies have been operative. Eventually definite layers or horizons are formed which are discernible when a vertical section of the soil is examined. The whole succession of horizons down to the unchanged parent material belongs to the soil, and is referred to as the soil profile. In different soils the colour, texture, structure, thickness, and the chemical nature of the various horizons differ in character. It is these characteristics of the successive horizons of the soil profile which are observed and made use of in identifying and classifying soils. The soil profile is discussed in greater detail in the section on "Soil Classification" (page 42).

The four main components of a soil are mineral matter, organic matter, moisture and air. In addition, there is present in the soil a host of living organisms of diverse size and kind. The latter, especially the minute micro-organisms, are essential to the proper functioning of the soil as a medium for plant growth.

Mineral Matter.—The mineral matter is composed of rock and mineral particles. These particles exist in all states of subdivision from that of coarse, easily visible particles of sand, to the finest particles of clay which are so minute as to be invisible even with the aid of a microscope. Silt is intermediate in size between sand and clay. Certain of the soil minerals exist unchanged in their original form, others are formed through chemical decomposition of the primary rock minerals and are, therefore, distinctive minerals of the soil. Among the latter are the extremely important minerals of the clay fraction, commonly spoken of as "clay" minerals.

Along with humus, the clay material makes up the most active and important portion of the soil mass. The clay imparts plasticity, cohesion and tenacity to the soil in proportion to the amount present. The clay and humus together greatly influence the fertility, structure and water holding capacity of the soil.

On the average, mineral matter accounts for over ninety per cent. of the weight of the dry soil. The texture of the soil is determined by

the percentages of clay, silt and sand which make up the mineral portion of the soil. Coarse textured soils have a high percentage of sand particles and fine textured (heavy) soils have a greater proportion of clay (Table 22).

Organic Matter.—Soil organic matter is derived from the remains of plants and animals which decompose in the soil. These organic remains occur in various stages of decomposition but are mostly present in the form of the dark coloured organic substance known as humus. The amount of organic matter which may be present varies from about one to twenty per cent. The climatic environment and the character of the vegetation are factors affecting the nature and amount of organic matter in the soil. The amount of organic matter in mineral soils may seem relatively small, but its effect on their physical and chemical nature is of great significance. In the first place, the organic matter is the main source and storehouse for the important element nitrogen. It is food for many living organisms, and affects such important conditions as the moisture retaining ability, structure, and aeration of the soil.

Pore Space and Soil Structure.—It is obvious that porosity is a condition essential to the storage and circulation of water and air in the soil, and to the penetration of plant roots. There are two factors which greatly affect the kind and amount of pore space in a soil. These are texture and structure. Texture, as has already been stated, refers to the proportion of sand, silt and clay particles in the soil, while structure refers to the forms in which these particles, together with the humus, may form aggregates, or compound particles. The resistance of these aggregates to abrasion, pressure, or slacking is of importance. Common types of structural aggregates are granules and clods. Soils of good structure are friable and easily tilled and in general these conditions are present in the highest degree in well granulated soils. Such soils have the highest possible water holding capacity, and at the same time permit quick penetration of moisture, and easy circulation of both moisture and air within the soil. The maintenance of good structure is an essential part of good soil management.

Sandy soils have relatively less pore space than clayey soils, although the individual pores are larger in the former. The greater pore space characteristic of fine textured soils can only be fully effective in providing for the movement of air and moisture if these soils are well granulated. There is no practical way of changing the texture of agricultural soils, but the structure can often be greatly modified through the addition of organic materials, or through the application of proper and timely cultivation.

Soil Moisture.—Insufficient soil moisture is a condition which commonly limits crop yields. This is particularly true of a prairie area. In such an area productivity is to a large extent dependent upon the efficiency with which moisture is absorbed and retained for the use of the plant. In order to fulfill this requirement, the soil must be of heavy texture, and of good structure. In addition, the topography must be favourable. The best soils of the prairie areas are, therefore, heavy soils of a naturally friable granulated structure and of gently undulating topography. However, heavy soils are less desirable in more humid

areas where they may become waterlogged. Sandy soils have low moisture holding capacity and in the drier areas crops on such soils frequently suffer from drought. Many sandy lands have shallow water tables which compensate to some degree for their otherwise low drought resistance. Soils with gravelly, sandy or stony subsoils are also very droughty soils.

The amount of moisture in the soils varies greatly. A "dry" soil as observed in the field is not entirely devoid of moisture, although none of the moisture present is available for plant growth. A "moist" soil contains water available to the plant, and it is such water which forms the nutrient solution to supply the plant with both water and essential elements. A "wet" soil may be excessively supplied with moisture inasmuch as waterlogging is detrimental to plant growth. The soil water occupies the spaces (pore space) between the particles and also forms films covering such particles. Thus the water makes close contact with the solid materials of the soil and is, therefore, in a position to exert one of its main functions, i.e., acting as a solvent of the essential nutrient elements.

Soil Air.—The soil air fills that portion of the pore space not occupied by moisture. The amount of air in the soil must, therefore, vary inversely as the amount of soil water. The air within the soil is quite similar to that of the atmosphere except that the former contains more carbon dioxide. This gas is important in the soil because it dissolves in water to form carbonic acid. The latter acts as a solvent of minerals and in this way assists in the process of making essential elements available to the plant. The oxygen of the soil air is necessary for the proper functioning of the root system of most plants and also to many micro-organisms of the soil. When there is an insufficient supply of air in the soil, conditions become unfavourable for the growth of most cultivated plants.

Soil Reaction.—The reaction of the soil solution (that is whether the solution is acid, neutral or alkaline) is a chemical condition of great importance to growing plants. In acid soils there is an excess of acids over neutralizing basic materials. Soils may be slightly, moderately, or strongly acid, higher acidity indicating an increasing need for lime.

In neutral soils neither acids nor bases predominate.

In alkaline soils basic compounds are in excess. Such compounds are the carbonates of lime and magnesia, which produce slight to moderate alkalinity, or the carbonates of sodium and potassium which give strongly alkaline reactions. Highly alkaline soils almost invariably contain some carbonate of soda (washing soda) and it is this salt which forms "black alkali." The term alkaline should not be confused with the term "alkali" commonly applied to saline soils. The latter may be only slightly alkaline and in rare cases even acid in reaction.

In speaking of soil reaction the term pH is in general use and the pH scale is a convenient method of indicating the degree of acidity or alkalinity. The neutral point of this scale is pH 7. Soils ranging from pH 6 to pH 8 are generally favourable to plant growth, although acid-loving plants thrive better in moderately acid (pH 5) to strongly

acid (pH 4) soils. Some plants tolerate alkalinity but few will grow in strongly alkaline soils. As indicated above "black alkali" is generally present in strongly alkaline soils which have reactions of pH 9 or higher.

The Nutrient Elements.—Plants manufacture food from simple compounds containing the essential elements. The essential elements are obtained from the air, water and soil. Certain elements, such as carbon, hydrogen and nitrogen, are required in relatively large amounts, others, notably potassium, calcium, magnesium and phosphorus, in moderate quantities. Still others are only needed in small quantities. The latter include sulphur, iron, boron, manganese, copper and zinc. There are probably a number of elements in addition to these which are essential to plant growth.

The important element carbon is obtained from the carbonic acid gas of the air, while hydrogen and oxygen are supplied in water from the soil. These two simple compounds are brought together within the green leaf and elaborated into the basic substances of all foodstuffs through the process of photosynthesis. Nitrogen is obtained from the soil, with the exception that inoculated legumes are able to absorb nitrogen directly from the air through the activities of bacteria inhabiting the roots of the plants. Nitrogen also enters the plant in simple compounds, the most common of which are nitrate salts. Within the plant it is elaborated into complex proteins essential to animal nutrition.

All other elements are derived from the soil. They must be present in sufficient quantities and be readily available so that the growing plant may obtain its supply as required. Water acts as both solvent and carrier of the nutrient elements. The nutrient enriched water flows into the plant through the tiny root membranes and upward to the green leaf surface where active manufacturing of foods is carried on. Water is, therefore, of triple importance. It is in itself a nutrient, is a carrier of nutrients, and is a powerful solvent of minerals supplying nutrients. Indeed, the film of water reaching from the minute mineral particle to the tiny rootlet makes a great bridge over which the inanimate materials travel to become parts of living organisms or to form the foods which give them growth and energy.

While each main component of the soil has been discussed individually in the above paragraphs it must be remembered that they are not actually separate. In the soil, mineral matter and organic matter are intimately associated in a complex, dynamic system. The soil water bathes and penetrates the external and internal surfaces of this mass while forming a solution of substances suitable to the nourishment of the plant. The soil air is sweetened by the presence of oxygen and also brings an active solvent to the soil in the form of carbonic acid gas. This whole complex system is leavened by a host of minute but tremendously active living organisms, without which the soil would remain a rather inert mixture of organic and inorganic materials incapable of satisfactorily sustaining the growth of a plant.

PLATE 1

Peter Pond Lake—Upper Churchill Basin.

North Saskatchewan River.

Description of the Area

Location and Extent.—The surveyed area is located in the northern portion of the southern half of Saskatchewan, between 53°12′ and 54°27′ North Latitude and 103° and 110° West Longitude. This area includes the settled agricultural lands north of Township 48, that is, north of a line running approximately from Aylsham in the east, through Prince Albert in the centre, to Marshall near the western boundary. Portions of the following sectional sheets of the Topographic Survey of Canada are included in the soil survey: Carrot River, Prince Albert North, Big River, Fort Pitt, Meadow Lake and Green Lake.

The southern boundary of the surveyed area is formed by the top of Township 48, while the Province of Alberta forms the western boundary. The eastern and northern boundaries are not so well defined and are more irregular, coinciding roughly with the present outer fringe of agricultural settlement. Thus the western section of the surveyed area extends from Township 49 northwards to the middle of Township 63—a distance of 87 miles: in the extreme eastern section, the survey extends from Township 49 to Township 53—a distance of only 30 miles. The width of the surveyed area from east to west is about 290 miles. The location and general outline of the area are shown in Figure 1 (page 11).

The total area represented by the maps comprises some 15,000 square miles or nearly 10 million acres. Due to the presence of forest reserves and other Crown lands which could not be traversed by road, only 9,880 square miles, or 6,323,000 acres, were actually mapped.

Relief and Topography.—The surveyed area forms part of the physiographic region known as the Great Plains section of the Interior Continental Plain of North America. In Western Canada this section comprises that area west of the Manitoba Escarpment which lies between the Laurentian Plateau or Pre-Cambrian Shield on the east and north, and the mountainous Cordilleran Region on the west. The present surveyed area lies in the northern end of the Saskatchewan section of the Great Plains, and reaches to within 80 or 90 miles of the southern border of the Pre-Cambrian Region.

The general slope of the surveyed area is to the east, conforming to the prevailing slope of the Great Plains. Complete information on the relief of the area is not available, since the base maps are only contoured at 100′ intervals. The present information indicates a maximum relief of 1,500′ to 1,600′. The highest elevation shown on the base map, near Meeting Lake, is 2,500′ above sea level; the lowest elevation, in the north-east corner of the area, is below 1,000′.

The surface of the area may be described as a nearly level to rolling glaciated plain with a general easterly slope. This description does not cover the important local topographical features or land forms which break the surface of the plain. The land forms include hilly to rolling uplands, lower plains of flat to gently rolling topography, valleys, glacial drainage channels, and escarpments. These may be recognized by their distinctive patterns of relief and slope and by the associated surface geological deposits. A clear picture of the

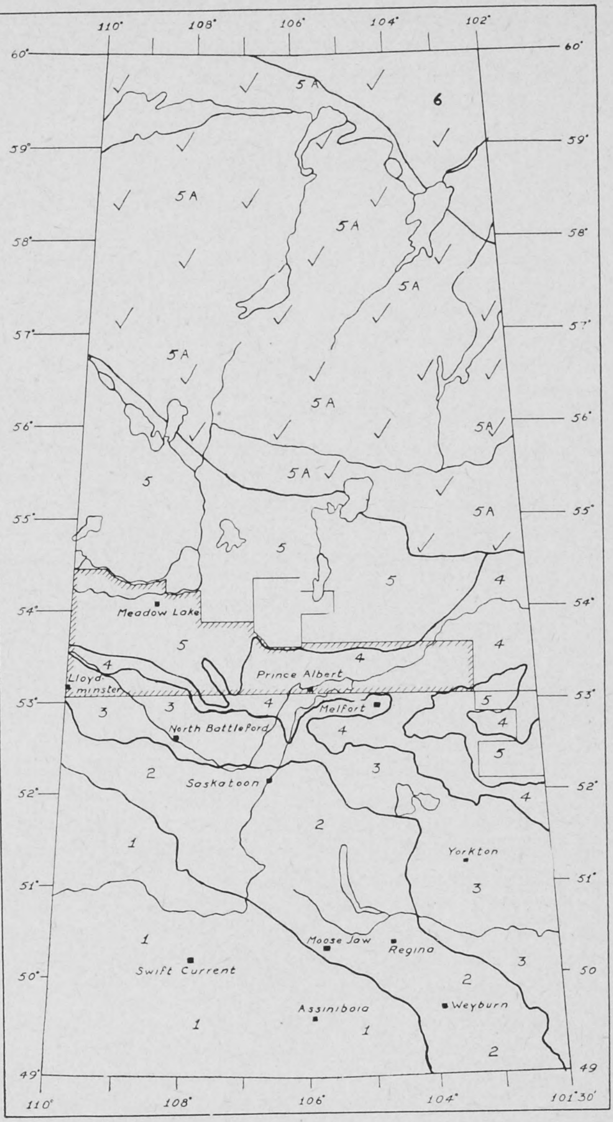

FIGURE 1

MAP OF SASKATCHEWAN SHOWING SOIL ZONES AND AREA COVERED IN PRESENT SURVEY

1. Brown Soils—short-grass prairie and western section of mixed prairie.
2. Dark Brown Soils—mixed prairie.
3. Black Soils—Parkland (prairie and wooded) vegetation.
4. Black-Grey Soils—mixed forest and parkland.
5. Grey-Podzolic Soils—mixedwood forest.

5A. Grey Podzolic Soils and Rock Outcrops—coniferous forest.

6. Transition Podzolic-Tundra Soils and Rock Outcrops—sub-arctic forest.

////// Boundary of present surveyed area.

physiography of the area may thus be obtained by considering the major plain as being composed of a number of more local land forms. These are listed and described below. The location of these features is shown in Figures 2 and 3.

TABLE 1.—IMPORTANT LAND FORMS OF THE SURVEYED AREA

1.—The Missouri Coteau and its western extension.
2.—The Prince Albert Park rolling upland.
3.—The roughly undulating to hilly Paradise Hill-Lloydminster Upland.
4.—The Beaver River Plain.
5.—The Turtleford Dissected Plain.
6.—The Debden Plain.
7.—The Shellbrook-Meath Park Marginal Plain.
8.—The Saskatchewan Lowland.

(1).—The Missouri Coteau.—The Coteau is a prominent eastward-facing ridge or low escarpment which enters the Province south of Weyburn, follows a general north-westerly direction to a point east of Biggar, and then runs north-easterly to enter the present surveyed area about 25 miles west of Shellbrook. Within this area, the eastward-facing slope of the Coteau runs northward to Hailsham and Timberlost, and thence north-westerly through the Big River and Meadow Lake Forest Reserves to a point about 10 miles south of Meadow Lake. Beyond this point it is difficult to determine the location of the Coteau escarpment. The ridge here turns westward, crossing the Meadow Lake and Bronson Forest Reserves and entering Alberta at about Township 58. To the north lies the lower plain occupied by the Beaver and Waterhen Rivers; north of the Waterhen is another rough upland area. It is possible that the original escarpment between the Meadow Lake upland and the upland just west of Flotten Lake has been eroded by the Beaver River. On the other hand, the westward-trending ridge south of Meadow Lake may also be regarded as the edge of the Coteau, which swings back eastward near Cold Lake to form a re-entrant north of the Waterhen River. It may be noted here that the upland south of Meadow Lake forms the divide between the Saskatchewan and Churchill River basins.

The Coteau marks a general change of elevation in the Great Plains. West of the Coteau the general elevation is higher than to the east. In the present surveyed area the eastern edge of the Coteau and the associated upland to the west range in elevation from 2,000′ feet to 2,500′ above sea level. The highest elevations occur near the eastern edge ranging from 2,400′ to 2,500′ between Meeting Lake and Meadow Lake. East of the Coteau the elevations range from 1,900′ to below 1,000′. It is considered that the change in elevation represented by the Coteau Escarpment is a reflection of bedrock conditions existing prior to glaciation. The surface of the Coteau (including the upland to the west) is chiefly rolling to hilly, and consists of wooded ridges and slopes interspersed with undrained depressions (lakes, ponds, meadows and bogs). The topography is that described by the geologist as knob and kettle, and is typical of glacial morainic deposits. Some areas, notably at Glaslyn and north-west of St. Walburg, are characterized by undulating topography.

(2).—The Prince Albert Park rolling upland extends from the Prince Albert National Park eastward to Candle Lake and the upper section of the Torch River. This morainic upland is topographically similar to the Coteau, although the general elevation is lower, ranging from 1,800′ to 2,300′.

(3).—The Paradise Hill-Lloydminster Upland is a roughly undulating to hilly upland in the south-west section of the area. The elevations of this upland range from 2,000′ to over 2,200′ except where it is trenched by the channels of the North Saskatchewan River and the Big Gully. The higher elevations consist of ridges and isolated hills which stand out by reason of their individual shapes, in contrast to the more monotonous pattern of the knob and kettle topography of the Coteau uplands. The Paradise Hill-Lloydminster Upland represents an area of Cretaceous bedrock which was only slightly modified by glaciation. Paradise Hill and Frenchman Butte appear to be small outliers or isolated remnants of the pre-glacial uplands, although the surface deposits are of glacial origin.

The remainder of the surveyed area consists of intermediate and lowland plains. The term "intermediate plain" is used to denote areas lying between the uplands and the lowest plain, and which in relief and topography form a transition between the highest and lowest lands of the area.

(4).—The Beaver River Plain.—This intermediate plain lies between the Coteau to the south and the rolling upland north of the Waterhen River. The elevation of the plain ranges from 1,600′ to 1,900′, and the topography is nearly level to rolling. In contrast to the uplands, the original glacial deposits have been modified in many places by water action giving rise to glacial lake and alluvial deposits. The eastern section of the plain in particular consists of water deposited materials, whereas the western section is chiefly composed of glacial morainic deposits.

(5).—The Turtleford Dissected Plain between the Paradise Hill Upland and the Coteau extends from St. Walburg south-east to Turtleford and Edam. This area ranges in elevation from 1,800′ at Edam to about 2,000′ near St. Walburg. The surface is undulating to rolling, and the area is dissected by a number of deep valleys which represent drainage channels formed during the melting of the glacial ice. These channels follow a southward trend from the western arm of the Coteau and reach the North Saskatchewan River. The intermediate character of this plain is indicated by the topography and the soils, both of which form a transition between the Paradise Hill-Lloydminster Upland and the Coteau. The surface deposits consist largely of morainic and modified (water-worked) glacial materials, with some lacustrine and alluvial deposits.

(6).—The Debden Intermediate Plain lies between the eastern escarpment of the Coteau and the upland associated with the National Park to the north-east. This plain ranges in elevation from 1,650′ to 1,900′, and in topography from flat to gently rolling. The area forms a low divide between Big River and Sturgeon River, which flow along its western and eastern margins respectively. The deposits include low morainic, modified morainic and glacio-fluvial materials.

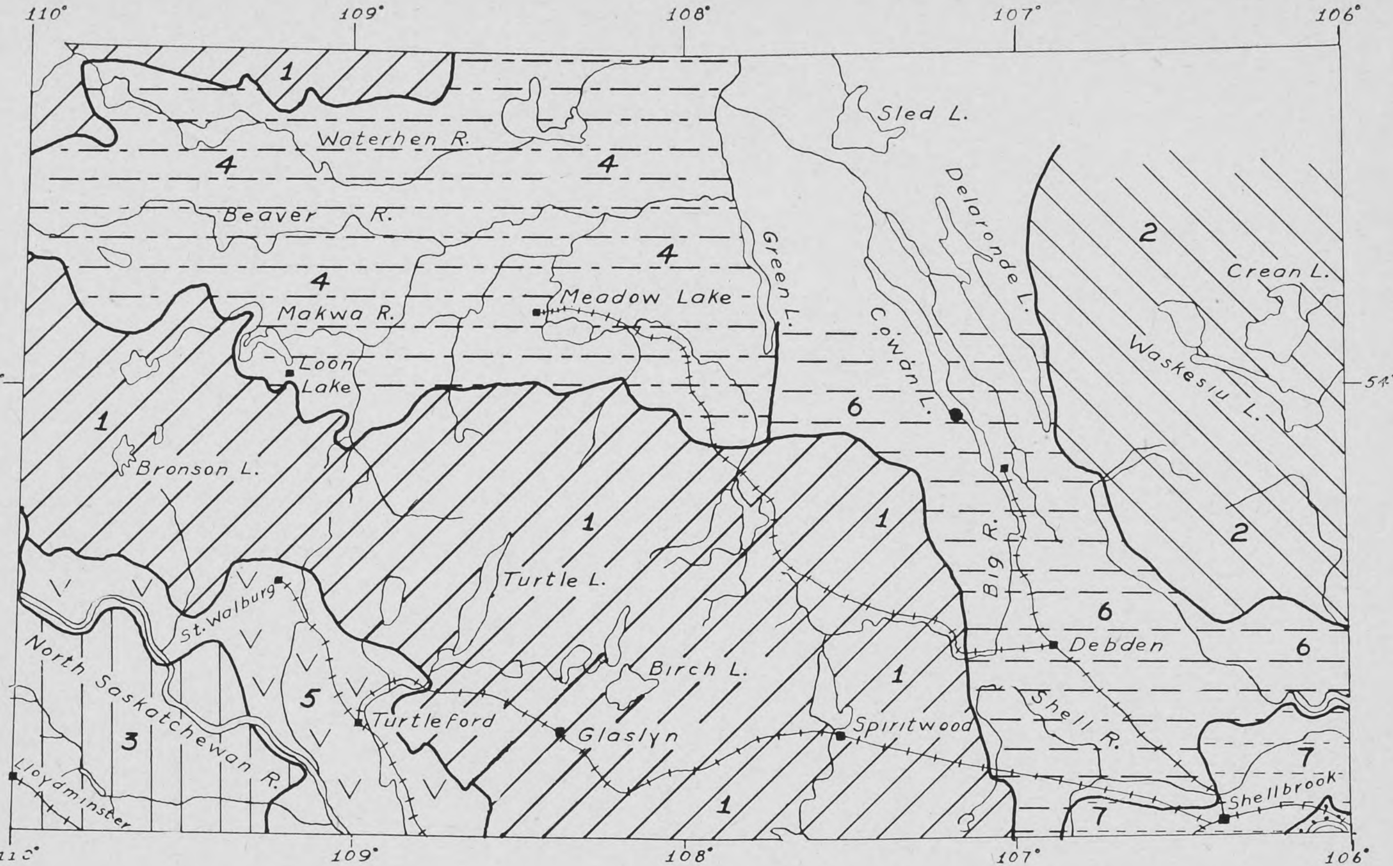

Figure 2
MAP OF WESTERN SECTION OF THE SURVEYED AREA SHOWING LAND FORMS AND DRAINAGE FEATURES.

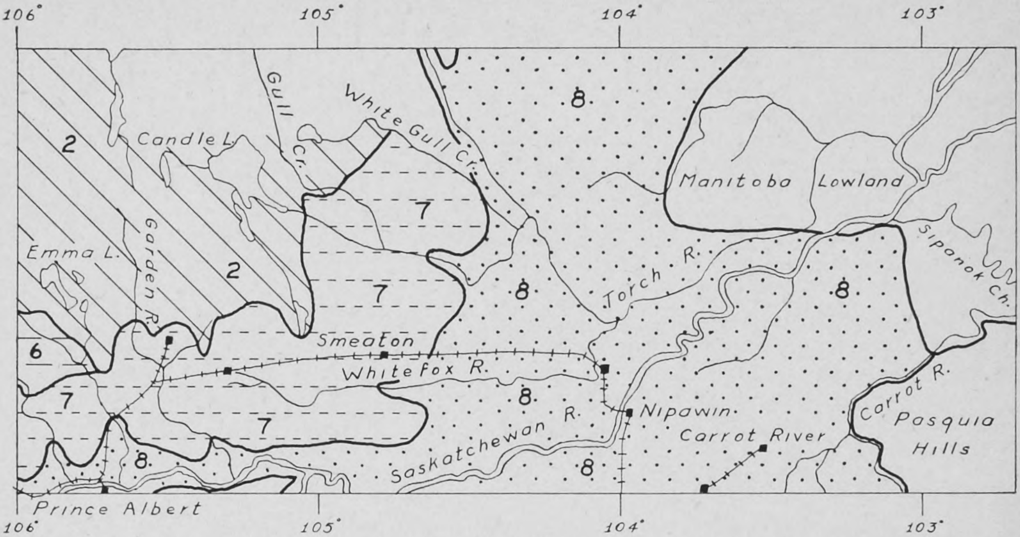

Figure 3

MAP OF EASTERN SECTION OF SURVEYED AREA SHOWING LAND FORMS AND DRAINAGE FEATURES.

FIGURES 2 AND 3
IMPORTANT LAND FORMS OF THE AREA

1. **Missouri Coteau and its Western Extensions.**
2. **Prince Albert Park Rolling Upland.**
3. **Paradise Hill-Lloydminster Roughly Undulating to Hilly Upland.**
4. **Beaver River Intermediate Plain.**
5. **Turtleford Dissected Plain.**
6. **Debden Intermediate Plain.**
7. **Shellbrook-Meath Park Marginal Plain.**
8. **Saskatchewan Lowland.**

FIGURES 2 AND 3
SKETCH MAP TO ILLUSTRATE PHYSICAL FEATURES

Legend

1. **Missouri Coteau Upland**—chiefly rolling to hilly glacial moraine—elevations 2,500′ to 2,000′.
2. **Prince Albert National Park Upland**—chiefly rolling to hilly glacial moraine—elevations 2,300′-1,800′.
3. **Paradise Hill-Lloydminster Upland**—roughly undulating to hilly, thinly glaciated Cretaceous bedrock—elevations 2,200′-2,000′.
4. **Beaver River Intermediate Plain**—nearly level to rolling glacial moraine and alluvial-lacustrine deposits—elevations 1,900′-1,600′.
5. **Turtleford Intermediate Plain**—undulating to rolling, chiefly glacial moraine and outwash. Some bedrock influence—elevations 2,000′-1,800′.
6. **Debden Intermediate Plain**—gently rolling to flat, modified glacial moraine and outwash—elevations 1,900′-1,650′.
7. **Shellbrook-Meath Park Marginal Plain**—chiefly undulating, modified glacial moraine and alluvial-lacustrine—elevations 1,650′-1,500′.
8. **Saskatchewan Lowland**—flat-depressional to very gently undulating glacial lacustrine and alluvial—elevations 1,500′-1,000′.

(7).—The Shellbrook-Meath Park Plain is a marginal plain bordering the lowland of the Saskatchewan River, and extending from near Shellbrook north-eastward to near Weirdale. The elevations range from about 1,500′ to 1,650′ and the topography is chiefly undulating. The surface deposits are largely water deposited glacial lake and alluvial materials, with water-worked or modified glacial till occurring on the higher elevations.

(8).—The Saskatchewan Lowland is the lowland plain extending along the Saskatchewan River from Prince Albert eastward. This plain lies below the 1,500′ contour and is characterized by nearly level to flat-depressional topography. It represents the lowest of the major topographic features of the present surveyed area. It is considered to represent an extension of glacial Lake Agassiz, which formed in Manitoba during the final retreat or melting of the glacial ice. The extension of Lake Agassiz in the surveyed area is referred to in this Report as the Saskatchewan Lowland to distinguish it from the Manitoba Lowland.

The Manitoba Lowland represents part of the lowest land occurring in the Agassiz lake-bed. It occupies the inter-lake area of Manitoba, and extends into Saskatchewan along the base of the Pasquia Hills and up to the junction of the Torch and Saskatchewan Rivers, just beyond the area covered in the present survey. The Saskatchewan Lowland forms a western extension of the Manitoba Lowland, but may be regarded as a separate area because it differs from the latter in surface features, bedrock geology and native vegetation.

The Saskatchewan Lowland consists chiefly of glacial lake and alluvial deposits. It is cut by the deep channel of the Saskatchewan River and the shallower channels of the Whitefox and Torch Rivers. The Lowland merges on the north and west with the marginal plain (No. 7) described above.

Each of the major topographic features of the land forms may be further subdivided into smaller units. These are associated with the soil areas shown on the map and may be referred to as soil landscapes. These landscapes are discussed in the section dealing with the soil associations.

Drainage.—Two main drainage basins are represented in the area—the Saskatchewan and the Churchill. The North Saskatchewan River drains the southern third of the area from the Alberta boundary to the junction of the North and South Saskatchewan Rivers east of Prince Albert. All of the surveyed area east of the junction is also drained by the Saskatchewan River. The Beaver River, which is part of the Churchill drainage basin, drains the northern two-thirds of the area from the Alberta boundary to the eastern border of the Prince Albert National Park.

The divide between these two drainage basins is formed mainly by the Missouri Coteau Upland, the higher elevations in the Prince Albert Park Upland, and the low divide between the Big and Sturgeon Rivers east of the Coteau escarpment.

The Beaver River is the main stream of the Churchill River system in the surveyed area. It rises in Alberta and flows in an

PLATE 2

Smooth, nearly level plain north of Prince Albert.

Rough, hilly upland north-east of Lloydminster.

(1).—Boulder clay consists of a mixture of rocks and minerals ranging in size from large boulders to fine clay particles. This type of deposit represents the materials transported by the ice and left behind as the ice melted. It is associated with medium textured (loam and clay loam) soils, the frequent occurrence of glacial stones and boulders, and a "wave-like" topography—a succession of knolls, intermediate slopes and undrained basins or sloughs. This pattern of relief and slope is evident even on the smooth undulating glacial till plain, and becomes greatly accentuated on the rough, rolling lands that constitute the morainic or knob and kettle topography.

TABLE 2.—SURFACE GEOLOGICAL DEPOSITS ASSOCIATED WITH THE PARENT MATERIALS OF THE SOILS

Deposit	Description
1. **Boulder Clay** (Glacial Till)	Unsorted morainic and resorted (modified) boulder clay deposits. Topography undulating to strongly rolling. Numerous glacial stones ranging from coarse gravel to large boulders.
2. **Thin Boulder Clay and Modified Bedrock**	Deposits varying from relatively thin boulder clay over Cretaceous bedrock to Cretaceous bedrock only slightly modified by glaciation. Topography roughly undulating to hilly. Less stony than 1.
3. **Glacio-Fluvial**	Glacial outwash sand and gravel deposits, including outwash plains, kames, eskers and stony stream-eroded glacial till; stone-free to excessively stony. Topography level to rolling.
4. **Glacial Lacustrine and Alluvial**	Glacial lake and alluvial sands, silts and clays; also includes lake-modified boulder clay. Topography flat to moderately undulating, and occasionally rolling. Stone-free to slightly stony.
5. **Aeolian**	Chiefly wind deposited fine sands; some very fine sandy-silty material in the area may also be wind deposited. Moderately undulating to rolling and dune topography. Stone-free.
6. **Recent**	Post-glacial deposits, including recent alluvium of streams and ponds, organic accumulations (peat and muskeg) and recent accumulations from wind and water erosion. Chiefly flat to depressional topography. Stones rare.

Referring to the major topographic features or land forms (page 12), the rougher morainic topography is characteristic of most of the Missouri Coteau (1), and also of the Prince Albert Park Upland (2). Mixed areas of rolling morainic deposits and smoother undulating resorted boulder clay occur on the intermediate plains—Beaver River (4), Turtleford (5), and Debden (6). Resorted or water-worked boulder clay is also associated with portions of the Shellbrook-Weirdale marginal plain (7). Boulder clay may also be encountered beneath glacial lacustrine, alluvial and aeolian deposits throughout the area.

(2).—Thin boulder clay and modified bedrock represent a variable mixture of materials transported by the ice and those derived from the underlying bedrock of pre-glacial times. The parent materials and the soils developed from them are strongly influenced by the

nature of the bedrock. In the present area, these parent materials are relatively low in lime carbonate and tend to produce medium to heavy textured soils with heavy compact subsoils of undesirable structure (solonetzic types of soils), underlain by saline lower subsoils.

In the present area, thin boulder clay and modified bedrock deposits occupy the Paradise Hill-Lloydminster Upland (3). The thin boulder clay deposits occur on the intermediate elevations, and are characterized by gently undulating to roughly undulating and gently rolling topography. The roughly undulating areas south of the Big Gully are characterized by long and narrow steep-sided ridges, varying in trend from east to south-east. Outwardly these ridges resemble eskers, but in most places where they are cut by roads, they expose a core of boulder clay or a dark, compacted, shale-like clay that is suggestive of bedrock.

The modified bedrock deposits occupy the higher elevations and the deeper depressions of the upland north of the Big Gully. These deposits consist of heavy clays weathered from Cretaceous bedrock shale. Heavy textured solonetzic and saline (alkali) soils have developed on these deposits, although in some places the clay is overlain by very fine sands which may represent local wind deposition.

It is probable that other sections of the surveyed area consist in part of modified pre-glacial deposits, but in view of the inadequate bedrock information it is impossible to determine the extent of such deposits. The soils west of the Missouri escarpment are lower in lime carbonate content than those to the east. This may indicate a different type of glacial deposit, or a thinner glacial cover with a greater proportion of lime-free bedrock in the soil parent materials. Some of the higher elevations in the Turtleford Plain suggest by their topography and associated soils that they are remnants of pre-glacial uplands. It is possible that modified bedrock deposits may also form the parent materials of some soils of the Saskatchewan Lowland.

(3).—Glacio-fluvial deposits represent coarse materials sorted from the boulder clay by streams that issued from the melting ice. The rapidly flowing water carried away most of the finer particles—clay and silt—leaving behind sand, gravel, pebbles, and stones. Hence these deposits are associated with coarse textured soils.

Deposits of sand or of sand and gravel occur on nearly level outwash plains, and also in glacial drainage channels. Shallow glacial spillways and the borders of deeper channels may be characterized by eroded boulder clay deposits in which boulders, stones, gravel, and coarse sand, overlie the boulder clay. Kames represent hillocks of roughly sorted boulder clay and are predominantly coarse textured. Eskers are long, sinuous ridges of sand and gravel, which look somewhat like a railroad grade.

In the surveyed area, glacio-fluvial deposits occur chiefly along streams and former drainage channels, and also between morainic areas and the outer margins of glacial lake beds. The more extensive outwash deposits occur along the North Saskatchewan, Monnery, Englishman, Turtlelake, Jackfish, Big and Spruce Rivers, on the divide north of St. Walburg, east of the Missouri escarpment, and from Christopher Lake to Candle Lake. Kames occur locally in rolling

morainic areas or as clusters of knolls and ridges on outwash and till plains.

(4).—Glacial Lake or Lacustrine deposits occupy the beds of former lakes which existed during the retreat of the ice sheet. These deposits consist chiefly of stone-free very fine sandy, silty, and clayey soils, associated with nearly level to undulating topography.

In the present area, glacial lake deposits occur at Meadow Lake, Turtleford, Shellbrook, and on the Saskatchewan Lowland. The latter is regarded as the western extension of Glacial Lake Agassiz. The lake bed in the Lowland is in some places covered by recent alluvial and windblown sands. In addition, some parts of the lake plain consist of lake modified boulder clay deposits. These deposits are stony, yet show evidence of water sorting and stratification.

(5).—Aeolian deposits consist of fine sands re-worked and deposited locally by the wind to form dunes, and very sandy to silty material that may have been transported for some distance. The latter type of wind deposit is associated with undulating to gently rolling topography, and is not easily distinguished at the surface from uniform lacustrine or alluvial deposits.

In the surveyed area, sand dunes occur north of the Saskatchewan River near the Alberta boundary, near Edam, west of Shellbrook, just north of Prince Albert, and along the Saskatchewan River to the east. The high proportion of sand and the frequent movement of the dunes result in light textured soils which are low in humus.

The finer sandy and silty deposits, known as loess, may overlie some of the modified bedrock north of the Big Gully. Other loessial deposits may be represented by the undulating to rolling very fine sands and silts of the Saskatchewan Lowland. In most respects, the soils developed on these deposits are essentially similar to those developed on lacustrine and alluvial deposits of the same texture. In the present area, however, the loessial soils are better drained. Further studies are required to determine the extent of loessial deposition.

(6).—Recent deposits represent materials laid down or accumulated on the surface since the close of the glacial period. Two main types of recent or post-glacial deposits occur in the area: namely, mineral and organic. Mineral deposits include recent deposits by streams during periods of flooding (alluvium). Materials washed or blown into ponds and other depressions may also be included, together with accumulations from recent wind and water erosion of cultivated land. The soils formed on recent mineral deposits are often immature or weakly developed.

The organic deposits consist of peat and to some extent decomposed peat or muck. Peat includes plant material in various stages of decomposition and also living plants in the form of sphagnum moss. The latter forms the bulk of the surface of bogs or muskegs. Peat deposits are associated with undrained basins and flat, poorly drained areas characterized by a high water table. Unlike the mineral deposits, the peat may be greatly modified or completely destroyed by fire. Thus, much of the original peat cover in the Saskatchewan Lowland has been destroyed during the development of agricultural settlement.

Recent deposits occur throughout the surveyed area, though often as small local areas. The flood plains of most of the present streams are narrow and in many places non-existent. Flood plain deposits (alluvium) occur in the valley of Big Gully Creek, Englishman, Turtlelake, Waterhen Rivers, and along the Saskatchewan near Prince Albert. In many places, the flood plain deposits are covered with shallow peat deposits. In other places, shallow peat, deep peat, and meadow or pond deposits occur. Such mixed deposits are referred to as Meadow-Bog soils, and the larger areas are indicated on the soil map. These are found south-east of Cold Lake, around Meadow Lake, in the Big River area, and throughout the Prince Albert-Carrot River area.

Climate.—The climate of Saskatchewan is dependent upon a number of natural factors. These include: the location of the Province in the interior of a continent, far removed from the modifying influence of the sea; its position in mid-northern latitudes, which results in relatively short growing seasons; and the presence of the Rocky Mountains to the west, acting as a partial barrier to the moisture-laden winds from the Pacific.

As a result of these and other factors, the climate of the Province is characterized by relatively low precipitation, the mean annual precipitation ranging from about 11″ to 18″. Futhermore, the precipitation is extremely variable, and wide fluctuations from the mean may occur. As an example, a meteorological station having a long-time mean annual precipitation of approximately 15″ shows a range of from 7″ to over 25″ between the driest and wettest years on record.

The climate is further characterized by great extremes in temperature between summer and winter, summer temperatures of over 100° F. and winter temperatures of below –50° having been recorded. There are also frequent wide fluctuations in temperature from day to day and between day and night. During winter low temperatures prevail, most of the winter precipitation being in the form of snow, and the ground may remain frozen for four to five months of the year. The summer growing season is relatively short, but the long sunny days partially offset this handicap. Usually over one-half of the total precipitation occurs in the growing season. The prevailing winds are westerly, and are characterized by the warm dry Chinook wind over south-western Saskatchewan, and colder north-westerly winds common to the whole region.

While the climatic conditions outlined above are representative of Saskatchewan as a whole, there are important differences between the more arid south-west section of the Province and the sub-humid eastern and northern regions. The climate of the south-west section may be referred to as a cool semi-arid type. East and north of this section the climate is of a sub-humid type, while the extreme north of the Province may belong to the sub-Arctic type of climate.

The climate of the present surveyed area belongs chiefly to the sub-humid type, although the south-western corner of the area is only a few miles from the northern boundary of the open prairie with its semi-arid climate. Compared with the southern half of the Province, the surveyed area has on the whole a shorter frost-free period, a

TABLE 3.—METEOROLOGICAL DATA AND SOIL CLIMATIC INDEXES FOR AVAILABLE STATIONS OF THE AREA

Station	Elevation	Mean Annual Ppt. (inches)	Mean Annual Temp. (F.°)	Mean Temp. Coldest Month (F.°)	Mean Temp. Warmest Month (F.°)	Soil Climatic Index
Waseca	2,115′	13.80	33.3	−1.5	61.9	45
Turtleford	1,925′	16.20	32.4	−1.8	60.7	58
Rabbit Lake	2,300′	15.69	31.8	−2.4	61.2	61
St. Walburg	2,050′	15.19	31.2	−4.6	62.8	63
Loon Lake	1,950′	16.26	32.3	−1.6	61.5	59
Witchekan	1,950′	15.02	32.1	−3.4	61.2	56
Prince Albert	1,414′	16.11	32.8	−4.4	63.4	56
Brooksby	1,400′	15.92	33.4	−3.3	65.8	52
Lost River	1,270′	14.91	31.9	−4.8	62.2	57
Nipawin	1,000′	16.50	33.0	−5.4	66.1	56

lower mean annual temperature and a similar to slightly higher mean annual precipitation. As a result, soil moisture conditions are generally favourable for crop growth, although the short growing season and occasional mid-season frosts are a hazard to crop production in many districts.

Meteorological data for the surveyed area and adjoining districts are given in Table 3. Available meteorological information does not adequately express local conditions of weather and climate. Few of the stations have long-time records, and there is also an insufficient number of stations within the area. Local climatic variations must, therefore, be inferred from the available records and from a study of native vegetation and soils. Mean monthly temperature and precipitation values are shown graphically in Figure 4.

Referring to Table 3 and Figure 4, it will be noted that the mean annual precipitation in the area ranges from 15″ to 16.5″, with Waseca, just south of the area, recording a mean of 13.8″. Mean annual temperatures vary from about 33° to 31° F. The mean temperature of the coldest month (January) falls below zero at all stations listed. Mean temperatures for the warmest month (July) range between 61° and 66° F.

As a comparison, records for the more arid sections of south-western Saskatchewan indicate a mean annual precipitation of about 11″ and a mean annual temperature as high as 40.5°; a mean temperature of 68.8° F. for the warmest month, and of 12.3° for the coldest month have been recorded. It will be noted that there is little difference between the mean warmest temperatures of south-west Saskatchewan and the present surveyed area, but that the temperature of the coldest month is considerably lower in the surveyed area.

The soil climatic index* given in Table 3 is an attempt to show the relationship between the temperature-evaporation factor and precipitation. At any given location, the extent of plant growth will depend partly on the amount of available moisture retained in the soil and partly on the activity of the evaporation-transpiration factors which govern losses of moisture to the atmosphere. The relation

*W. Millsap—Relating the soil moisture efficiency to Saskatchewan Soil Zones. Unpublished Manuscript, Saskatchewan Soil Survey, 1939.

PLATE 3

Parkland, Lloydminster area.

Sedge-grass and willow on alluvial flat of Beaver River. (Oat crop in foreground.)

between these two conditions has been referred to by the term "soil moisture efficiency." In the more arid sections of the Province an inch of available water stored in the soil will not produce as much plant growth as an inch of available water stored in a soil of similar composition located in a more humid area. In the arid section, more water is required to produce a pound of straw or grain, because a larger amount of water is lost by evaporation and transpiration. It may, therefore, be said that the arid area has a lower soil moisture efficiency than the humid area.

The values derived from calculating the soil-climatic index from available meteorological records have given good agreement with the variations in soil moisture efficiency occurring in different parts of the Province. For the present area, the index values given in Table 3 vary from 52 to 63. By comparison, soil-climatic indexes for the more arid section of the Province range from 33 to 24. In the present area, the less humid climate of the south-west section is indicated by the low index for Waseca. This station is situated in an area of thin black soils, about twenty miles from the border of the Dark Brown Soil Zone.

Table 3 contains data available up to 1945. The soil climatic indexes are 3 to 4 points lower than the corresponding indexes given in Soil Survey Report No. 12, which were based on data available up to 1932. The differences are presumably due to the lower precipitation and higher temperatures recorded during the drought period of 1930 to 1940.

An additional study of the data shown in Figure 4 brings out some interesting meteorological differences between the eastern and western sections of the surveyed area. In the western section, represented by Witchekan, Turtleford, St. Walburg, and Loon Lake, the highest monthly precipitation occurs in June with the next highest amount in July. The eastern section, represented by Brooksby, Lost River, and Nipawin, is also characterized by high June precipitation. However, the records show that September precipitation approaches or surpasses that of July. This means that the eastern section receives a considerable amount of precipitation in the fall, after summer growth has ceased. It is evident that this late rain would tend to store soil moisture for the next season, since very little would be lost in the fall by evaporation and transpiration. This may partly explain why light-textured soils in the eastern sections are apparently more drought resistant than might be expected. Such soils are usually underlain by heavier textured deposits, which would have the effect of creating a storage reservoir. The fall precipitation in the eastern section is also associated with a less desirable situation—that of frequent wet weather during harvest.

Detailed information on the length of the growing season and frost-free period for the surveyed area is not available. However, some general information is given in a publication of the Dominion Bureau of Statistics* and also in the "Saskatchewan Guide."** The

*Agriculture, Climate and Population of the Prairie Provinces of Canada. A statistical atlas, Bureau of Statistics, Ottawa, 1931.

**Guide to Farm Practice in Saskatchewan, 1948. See section on Climate prepared by Prof. B. Currie, Department of Physics, University of Saskatchewan.

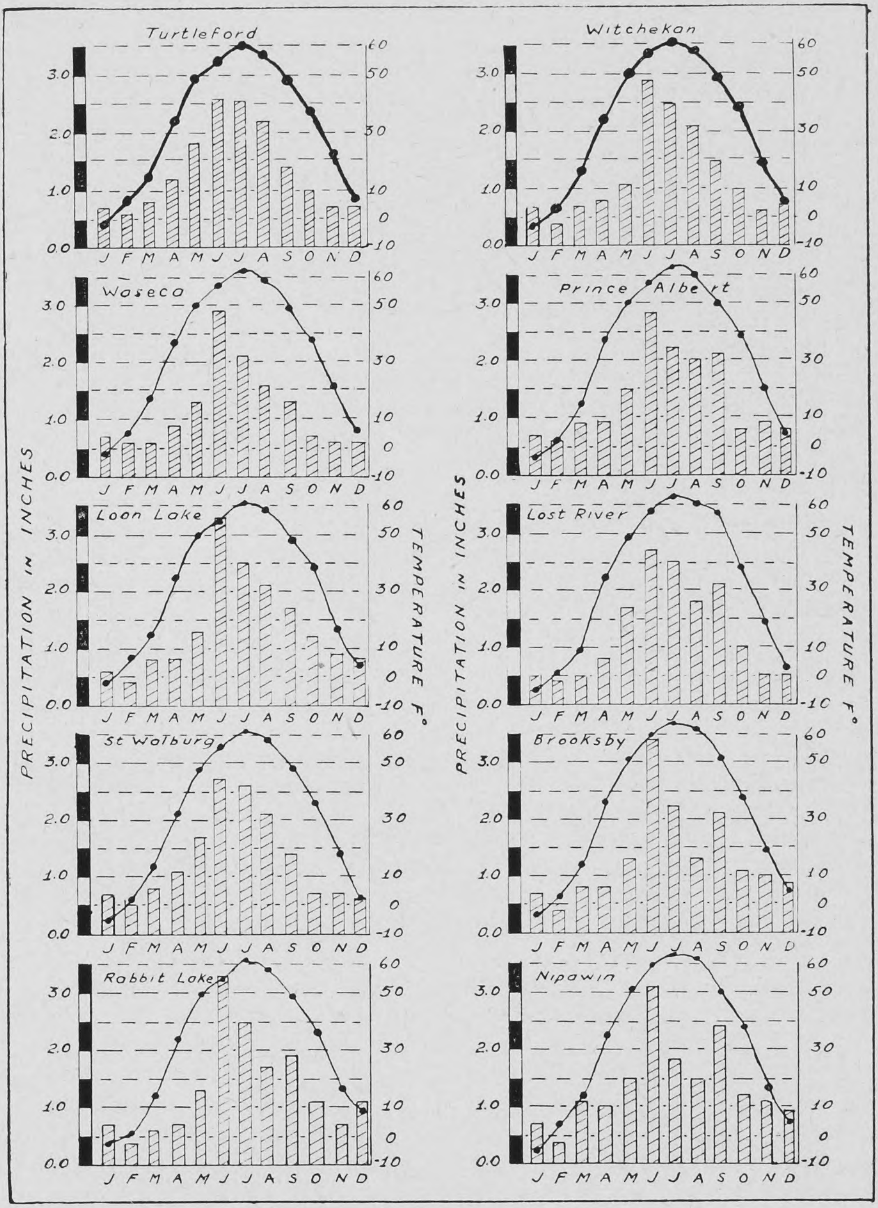

Figure 4

GRAPH SHOWING MEAN MONTHLY TEMPERATURE AND PRECIPITATION AT SELECTED METEOROLOGICAL STATIONS

latter contains an interesting discussion on the source of Saskatchewan weather, and should be referred to as an additional source of information on the climate.

The first-named publication contains information on the average length of the period between the last killing frost of spring and the first killing frost in the fall. A killing frost is defined as a temperature of 29° F., which is regarded as critical for cereal crops. The information indicates that the western area, from the North Saskatchewan River and beyond, has less than 100 days between killing frosts. This area extends eastward to the northern section of the Debden-Big River plain. Most of the remainder of the area has a period of 105 to 110 days, with a small area around Prince Albert reaching 110 to 115 days. By comparison, Saskatoon and Swift Current are in an area having over 120 days between killing frosts.

It may be expected that local weather conditions will vary throughout the surveyed area. Such factors as elevation, degree and direction of slope, type of soil, and vegetative cover may affect the length of the growing season, the incidence of damaging frost, and the processes of transpiration and evaporation which influence the soil moisture efficiency.

Native Vegetation.—In preparing this section of the Report, valuable assistance was received from the workers listed below.* They also compiled a list of important plant species of the surveyed area, as given in Table 26, page 237.

The native vegetative cover of the surveyed area represents both Forest and Grassland. The main area of grassland coincides with the main area of black soils, and occupies the somewhat less humid south-western section of the surveyed area. This section covers most of the Paradise Hill-Lloydminster Upland and the adjoining western and southern portions of the Turtleford Plain. Small areas of grassland, also associated with local islands of black soils, occur within the Forest formation. Such areas occur on dry southern slopes of hills and ridges, and on coarse sandy-gravelly deposits along stream channels. These sites are presumably too arid for the establishment of a permanent wooded cover, and the grass is, therefore, able to compete with the trees.

The black soils, which are found chiefly under a grassland cover, represent only 12.5 per cent of the soils mapped. Hence, the greater portion of the surveyed area lies in the forest region with its associated grey podzolic, wooded calcareous (limy) and muskeg or bog soils.

The grassland of the present area represents the northern end of the Parkland section of the Grassland Region of Saskatchewan. This section is characterized by a mixed cover of grasses and broad-leaved plants, interspersed with clumps or "bluffs" of trees and shrubs. In classifying the distribution of the important plant species of the Parkland, both Prairie and Wooded types of vegetation were recognized.

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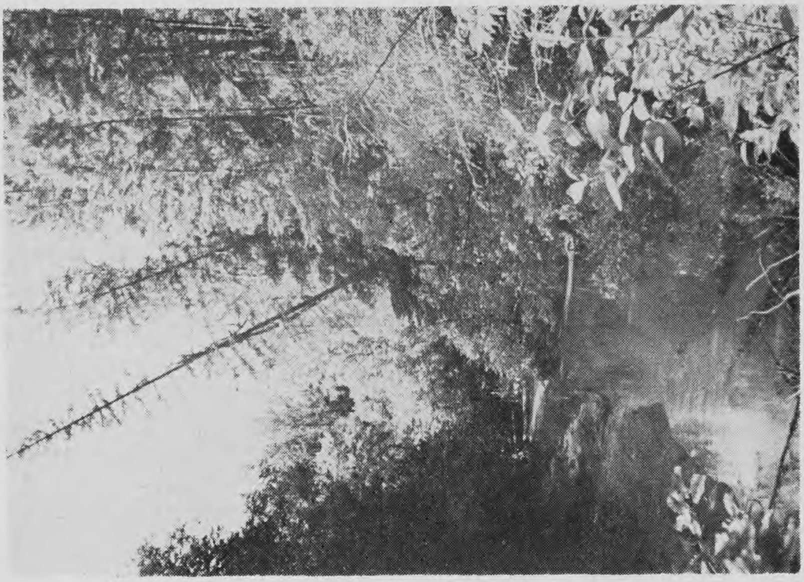
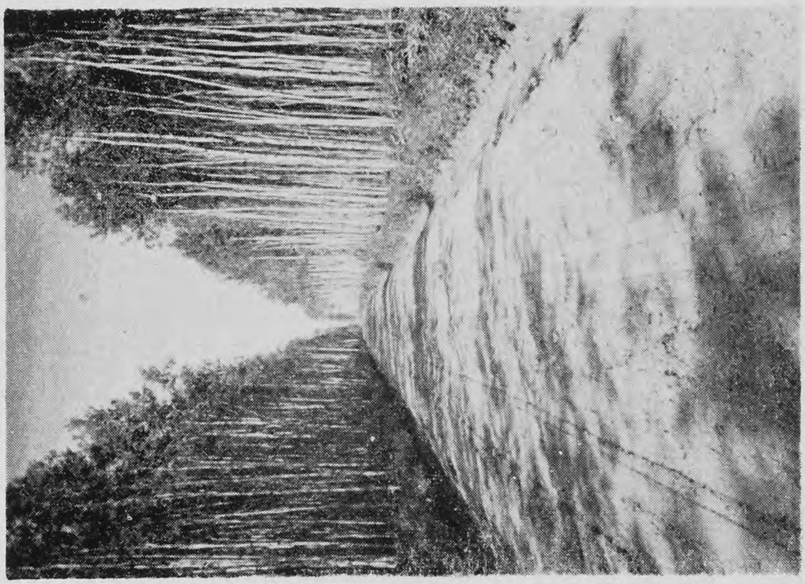
*Dr. R. C. Russell, Dom. Lab. of Plant Pathology, University of Saskatchewan; Dr. J. L. Bolton, Dom. Forage Crops Laboratory, University of Saskatchewan; R. T. Coupland, Professor of Ecology, University of Saskatchewan.

PLATE 4



Mixedwood forest, showing coniferous and broad-leaved trees.



Aspen poplar stand in forest area.

The Prairie type of Parkland vegetation includes northern wheatgrass, slender wheatgrass, awned wheatgrass, Hooker's oatgrass, rough fescue, June grass, Mat Muhly, and short-awned porcupine grass; involute-leaved sedge and sun-loving sedge are also representative. Among the broad-leaved plants are various wild flowers and fruits and shrubs; these include strawberry, prairie rose, anemone, golden pea, wolf willow, snowberry, and other species which are listed in Table 26.

The wooded type of Parkland vegetation consists of aspen and balsam poplars, various willows, chokecherry, saskatoon berry, and dogwood; in addition, various grasses and broad-leaved plants are associated with the fringes of the treed areas. These species include awned wheatgrass, fringed brome, hoary wild rye, pea-vines, roses, and others.

The pattern of the Prairie and Wooded types of vegetation varies with the features of topography and drainage. In hilly and rolling areas it frequently happens that the more moist northern and eastern slopes are thickly wooded, while the more arid and droughty southern and western slopes carry a prairie vegetation. The same sequence occurs on the steep banks of coulees and valleys. Wolf willow occupies well-drained sites in the grassland areas.

In areas where the soils and topography are well suited to arable agriculture, little native grassland remains, except in occasional farm pastures and along the roadsides. In rougher areas, considerable native vegetation still exists, and this is particularly true of the rolling to hilly upland between the Big Gully and the North Saskatchewan River. Here good stands of prairie grasses may be observed, with occasional clumps of small aspen poplar. It is probable that the difficulty of obtaining a water supply, which is a characteristic of this area, has prevented the full use of the grassland for grazing purposes.

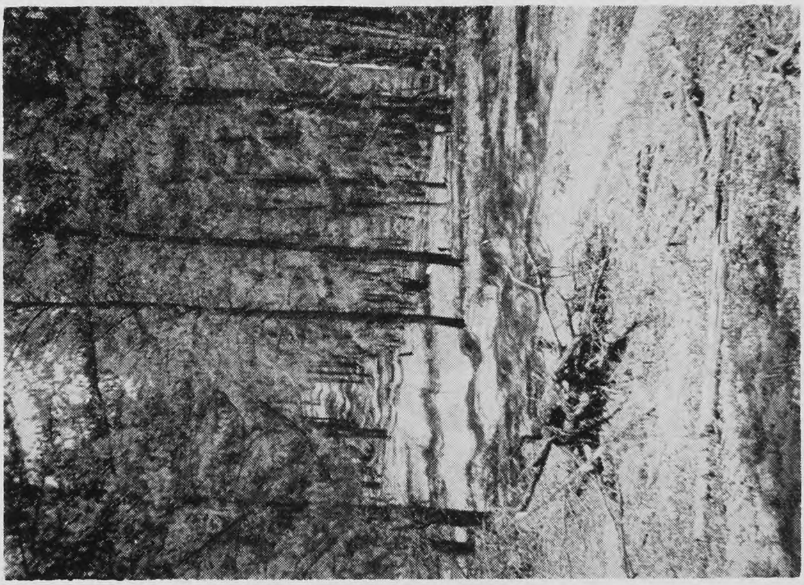
The Forest formation belongs to the Mixedwood section of the Boreal Forest Region of Canada, as defined by Halliday.* The vegetation consists of a mixture of deciduous and coniferous trees, including aspen, black poplar, white spruce, black spruce, balsam fir, and white birch. Cranberry, hazel, willows, and other shrubs and flowering plants are also associated with the tree cover. Jack pine is usually the dominant tree on sands, while black spruce and tamarack are common in the sphagnum bogs or muskegs. Wet marshy areas are often bordered by willows, with sedges, cat-tails and bulrush occupying the central depression. Shallow deposits of peat are also associated with this vegetation. It may be noted that tamarack and sphagnum are usually associated with acid conditions, while willows and sedges occur where the soil reaction is neutral to alkaline, and particularly where lime carbonate is present. Various grasses, fireweed, and broad-leaved plants are common in burned-over areas.

In general, well drained upland soils of medium texture are characterized by a preponderance of aspen and black poplar. It is possible that white spruce and birch were formerly more common, the numerous fires having destroyed the original stands. In some areas small spruce trees are regenerating under the main poplar cover.

*W. E. D. Halliday—"A Forest Classification for Canada." Dept. of Mines and Resources, Ottawa; Bulletin 89, 1937.

PLATE 5

Mixedwood forest—aspen in foreground, white spruce in background.



Jack pine stand on sandy soil.

The effect of fires, logging, and the clearing and breaking due to agricultural development have destroyed much of the true forest cover. The best stands of trees are now found in the forest reserves and the provincial and national parks. A feature of the true forest is the much taller growth habits of the aspen, black poplar, and willow as compared with their growth in the parkland area.

Throughout the surveyed area, other important differences in both species and habits of growth are to be found under different soil and topographical conditions. For example, distressed habits of growth are common to trees growing on highly leached, coarse sandy and gravelly soils. On such sites, the trees, largely aspen, form a more open stand, and the individual trees are shorter and more branched than those found on the heavier textured soil. Interesting information on local plant associations and other features of the forest region is contained in the report of the Big River Survey.*

An important feature of the vegetation of the surveyed area is the presence of wild fruit-bearing plants. These include saskatoon berry, chokecherry, cranberry, blueberry, raspberry, gooseberry and strawberry. These fruits are a valuable source of food for residents of the area, and to some extent are harvested commercially and sold in urban centres.

The ecological character of the major soil zones of the Province are indicated in the legend of the soil zone map (Figure 1, page 11). The list of principal plant species of the surveyed area is given in Table 26.

Natural Resources.—The natural resources of the Province consist mainly of agricultural and forest land, minerals, oil and gas, fish and game, and public domain. Of these, agricultural land is by far the most important both as regards the number of people who obtain their livelihood from the land and the relative values of agricultural products as compared with those from other resources. A classification of land areas is given in Table 4.

TABLE 4.—CLASSIFICATION OF LAND AREAS OF SASKATCHEWAN**

Non-forested	62,500,000 acres
Forest	55,400,000 acres
Waste (rock, open muskeg, roads, urban, etc.)	34,400,000 acres
Total land area	152,300,000 acres
Cultivated land (crop, fallow)	33,570,000 acres
Total occupied land (cultivated, native pasture, woodland)	60,000,000 acres

The area covered by the present survey lies principally in what is known as the mixed farming area, with the northern and eastern borders extending into the unsettled forest region. The south-west section, from Turtleford to Lloydminster, is classified with the grain farming area, in which grain production, chiefly wheat, is the main enterprise. This division into mixed farming and grain farming is only a rough separation, but it follows approximately the separation of the

*Rawson, Hope, Mitchell, and Tisdale—The Big River Survey—a study of Natural Resources, University of Saskatchewan, 1943.

**Canada Year Book, 1947. Figures rounded off to approximate totals.

area into black soils on grassland and degraded and grey soils on forest land. The greater ease of cultivation in the grassland and the somewhat less humid climate tend to favour wheat production.

The mixed farming area represents a type of agriculture in which grain production is still the main enterprise, but in which more coarse grains, forage crops and livestock are produced. Wheat sales represent only one-sixth to one-quarter of the farm income in the forest area.* Some sections, notably Choiceland and Carrot River, are producing special crops such as alfalfa seed, rape seed, and field peas and beans. Alfalfa seed is also produced on the Big River Plain in the north-west section of the surveyed area. Native hay production is associated with meadow areas where sedges and meadow grasses can be utilized when the surface is dry enough to permit cutting and stacking. Large native hay meadows occur in the Meadow Lake, Spiritwood, and Big River areas. Some upland hay is also available in the hilly grasslands north of the Big Gully valley. Throughout the whole area, but particularly in the forested portion, certain individual farmers have developed excellent gardens and fruit plantations. Some of these are producing on a commercial scale. An enterprise which may be associated with gardening and fruit production is that of bee-keeping. Finally, there are several nurseries where trees, shrubs, flowers and vegetables suited to the area are produced.

The unsettled forest land is now largely in forest reserve, and the production of logs, ties and fuel-wood is under the supervision of the Provincial Department of Natural Resources. This supervision and other plans for future control and development are made necessary by the drastic depletion of merchantable timber caused by ruthless exploitation, fires, and the clearing of lands intended for agricultural development. The problem of the Saskatchewan forests is fully dealt with in a special report.** In the present surveyed area it may be stated that, with the exception of established forest reserves and parks, very little merchantable timber remains. In some agricultural areas, little wood for fuel and fencing is available, and the farmsteads may even lack the protection of a native shelter belt. The modern methods of clearing and piling trees have the disadvantage of encouraging the clearing and breaking of large blocks of land, with the result that the retention of wood-lots and shelter belts is apt to be overlooked.

While there is still considerable land to be cleared and brought under cultivation, the bulk of the good agricultural land of the present settled area of the forest region is already settled. Extension of the arable area eastward along the Carrot River appears to be feasible but in general the present limits of agricultural settlement coincide with rough topography, light textured soils or very poorly drained areas. Finally, it should be emphasized that the full development of agriculture is in many districts held back by the lack of a good water supply, and in some districts by the lack of railway facilities.

The remaining resources which are being utilized in the surveyed area include oil and gas in the vicinity of Lloydminster, commercial

*R. A. Stutt and H. Van Vliet—"An Economic Study of Land Settlement, etc." Department of Agriculture, Ottawa, Publication 767, 1945.

**Report of the Saskatchewan Royal Commission on Forestry. The King's Printer, Regina, Saskatchewan. 1947.

fishing in the northern lakes, and trapping in the unsettled forest area. In addition, some fur-bearing animals are raised on fur farms. The total values of the products from natural resources and agriculture in Saskatchewan are given in Table 5, since it is not possible to secure them for the surveyed area alone. However, much of the lumber, fish and fur comes from the surveyed area or from adjacent areas. The same is true of oil and gas.

TABLE 5.—VALUE OF PRODUCTS DERIVED FROM NATURAL RESOURCES AND AGRICULTURAL LAND IN SASKATCHEWAN*

Forest Products	$ 6.175,223
Coal	3,068,826
Petroleum and Natural Gas	1,738,207
Metals	26,911,795
Clay and Clay Products	509,530
Sodium Sulphate	2,194,710
Sand and Gravel	1,245,065
Fur (Farm)	251,593
Fur (Wild)	1 992,274
Fish	1,282,437
Total	$ 45,369,660
Agricultural Production**	567,447,000

The public domain, represented by provincial and national parks and their associated resorts, is an important feature of the area. Prince Albert National Park, with its main resort on Waskesiu Lake, occupies about 1,000,000 acres. Provincial parks and resorts include Emma Lake, Loon Lake, Sandy Lake, and Round Lake. Nipawin and Lac La Ronge parks are two attractive areas which are likely to be very popular when developed. The various parks not only provide holiday facilities for residents and tourists, but in addition they preserve the native landscape, water, vegetation, and wild life. In view of the disappearance or changes in these features resulting from settlement, the parks will become more and more valuable as time goes on.

Transportation and Marketing Facilities.—The surveyed area includes well-developed agricultural settlements, the so-called pioneer fringe of settlement, and unoccupied forest lands. In general, transportation and marketing facilities vary with the degree of development. The location and number of railway lines, roads, towns and villages provide adequate services in most of the well settled districts. Even in the older settlements, however, some localities are somewhat isolated due to the barriers formed by major rivers or rough topography. Examples of such localities are south of the Saskatchewan River and just east of Fort a la Corne Forest Reserve; east of Prince Albert, on either side of the North Saskatchewan River; just south of Emma Lake and the National Park; and in the fork of the Saskatchewan and Big Gully valley. In these districts settlers may be located 12 to 20 miles from a marketing centre.

As may be expected, the newer settlements, forming the present fringe of the agriculturally developed lands, are very poorly served by railway and urban facilities. This is particularly true of the areas north of St. Walburg, extending to Loon Lake, Goodsoil and Pierce-

*Annual Report, Saskatchewan Department of Natural Resources, Year Ending 31st March, 1949.
**Canada Year Book, 1949.

land. Since St. Walburg is the end of steel to the south, and Meadow Lake the end of steel to the east, settlers in the most north-westerly section at Goodsoil and Pierceland are 60 miles from a railway point. Elevators at Goodsoil and other "inland" points enable the farmers to market grain within a closer distance. There still remains, however, the high cost of transporting the grain, or livestock if the grain is fed locally, to the rail-head. Roads are being improved in these remote areas and it may be expected that all-weather highways will ultimately connect the area with railway points. The fact that marketing can be accomplished over such long distances is due to the use of the modern truck and the gradual improvement in the roads.

New settlements are developing at the eastern edge of the area, north-west of Nipawin and north and north-west of Carrot River. Here the end of steel is at Nipawin and Carrot River respectively, and so far settlement has not extended much beyond 25 miles from the railway.

The railway lines and shipping points are shown on the soil map. The location of highways and municipal roads may be secured from current road maps issued by the Provincial Government. In most of the surveyed area the present gravelled highways closely parallel the railway lines, so that while communication between railway points has improved, there is a need for more gravelled roads to connect rural districts with the main highways and railway facilities. The main highways from Prince Albert to the National Park, from Glaslyn to Meadow Lake and from St. Walburg to Loon Lake run at right-angles to the railway lines, and thus connect the northern fringes of settlement with the older settlements to the south.

Main urban centres in the area include the city of Prince Albert and the following towns and villages: Lloydminster, Nipawin, Meadow Lake, Big River, Turtleford, St. Walburg, Loon Lake, Shellbrook, Paddockwood, Whitefox and Spiritwood. There are many other important railway points, and in addition a number of rural hamlets which are located beyond the present railway lines. These hamlets provide local shopping, garage and post-office facilities for the more remote settlements.

The railway lines belong to the C.N.R. and C.P.R. systems. The oldest lines include the C.N.R. line from Saskatoon to Edmonton which passes through Lloydminster, and the C.N.R. line from Prince Albert to Big River. Most of the other lines were constructed between 1928 and 1932 and, therefore, are of more recent construction than other railway lines in the Province. Information on the dates of completion of branch railway lines in the northern settled areas is given in the publication listed below.*

In addition to railways and roads, transportation is also effected by air lines. Northern Saskatchewan is served by Provincial Government Airways operating from Prince Albert. The latter city in turn is linked by Canadian Pacific Airlines with Saskatoon, Battleford and Regina.

*R. A. Stutt and H Van Vliet—An Economic Study of Land Settlement in Representative Pioneer Areas of Northern Saskatchewan, Dominion Department of Agriculture. Publication No. 707, 1945.

History and Settlement.—The first recorded history of Saskatchewan dates from the travel of the early explorers and fur-traders into Western Canada. When the first white men visited the region, they found the country inhabited by Indians. The latter are, therefore, the first inhabitants of whom we have record. They lived a nomadic life as hunters and fishermen and apparently had not learned the art of cultivating the soil. With the coming of the white men, the hunting of fur-bearing animals and buffalo as a means of exchanging furs for manufactured goods became an important activity of the Indians.

From 1670 to 1870 the Hudson's Bay Company claimed authority over what is now Western Canada, although this claim was frequently disputed by the French until Canada finally became a British possession. The struggle between the Hudson's Bay Company and rival Canadian companies for control of the rich fur trade of the north-west resulted in the explorations that finally made the country known to the outside world, and paved the way for agricultural settlement when the fur trade declined. The early missionaries also contributed to our knowledge of the country.

The surveyed area has important associations with this early history, since the Saskatchewan River formed the main route of travel for Indians and white men alike. In 1690 the Hudson's Bay Company was faced with the almost complete loss of its fur trade following the capture of Company posts on James Bay by the French under De Troyes and D'Iberville. The Company decided to send a representative into the unknown western region to persuade the Indians to hunt beaver and bring them down to York Factory on Hudson Bay. A young man, Henry Kelsey, was chosen, and in 1690 he set out from York Factory with some Indians who were returning to the west. The party went up the Hayes and Fox Rivers to Cross Lake, thence up the Minago River to Moose Lake and from there to the Saskatchewan River. A base camp was made at Deering's Point—about 12 miles below The Pas. From this camp, Kelsey journeyed to the upper waters of the Red Deer River near Nut Lake, and thence southward to the vicinity of the Touchwood Hills. He was the first white man to see the plains north of these Hills and east of the location of what is now the city of Saskatoon. Kelsey's journal contains the first description of the buffalo and of the Plains Indians. It is of interest to note that Henry Kelsey rose to be Governor of the Company he had served so well. Much of our information concerning Kelsey and other early traders and explorers is due to the work of the late Professor A. S. Morton,* who, as head of the Department of History of the University of Saskatchewan, made a special study of the fur trade in Western Canada.

The struggle between the French and English continued until, by the building of Fort Paskoyac at The Pas in 1749, and of Fort St. Louis by La Corne in 1753, the French were able to divert most of the furs from York Factory to Montreal. La Corne's fort was situated on the Saskatchewan River north of Kinistino. The names of Kelsey and La Corne are perpetuated in Kelsey Lake and Creek and Fort a la Corne Forest Reserve respectively. Their names are also given to two of the soil associations mapped in the area.

*Arthur S. Morton—"Under Western Skies." Nelson and Sons, Toronto, 1937.

PLATE 6

Agricultural land is the most important natural resource of the area.

Hudson's Bay Trading Post, Montreal Lake. The fur trade remains important throughout the north.

In 1754 Anthony Henday, a servant of the Hudson's Bay Company was sent out from York Factory on an excursion similar to that undertaken by Kelsey. Henday went up the Carrot River, crossed the South Saskatchewan near Fish Creek, and continued west and south until he reached the area near the present town of Didsbury in Alberta. Here he spent the winter, and was the first white man to see the Canadian Rockies.

Between 1754 and 1774, about sixty journeys of this nature were made by the Hudson's Bay Company's staff into the west. One of them, William Pink, spent a winter north of Saskatoon, and later (in 1767-68), journeyed up the Beaver River almost as far as Lac la Biche. According to Professor Morton, he was probably the first white man to pass near the present town of Shellbrook and up the Shell River. He continued west and passed near what is now Turtleford, finally reaching the Beaver River. A year later James Finley of Montreal came up the Saskatchewan to a fort north of the present Codette, built by a French-Canadian named Francois le Blanc. These men represented a group of Montreal traders who formed the North-West Company. Their western associates were known as the "Pedlars" because they carried their goods right to the camps of the Indians. Thus, they were able to compete with the Hudson's Bay Company, and once again the latter organization sent a servant to report on the situation. This time it was Matthew Cocking who came up the Saskatchewan as far as La Corne's deserted fort. There he left the water and travelled overland to north of the Birch Hills, crossed the South Saskatchewan west of the present St. Louis, and reached the neighbourhood of the present town of Biggar. Later he crossed the North Saskatchewan on the ice and visited the Wood Crees who trapped beaver in the Thickwood Hills. In 1774, Samuel Hearne, with Matthew Cocking as his assistant, was sent to establish a post somewhere near The Pas in order to draw the Indian trade away from the Pedlars. The site finally chosen was on Cumberland Lake, and Cumberland House, as the post was named, has been in operation ever since—the oldest permanent settlement in Saskatchewan.

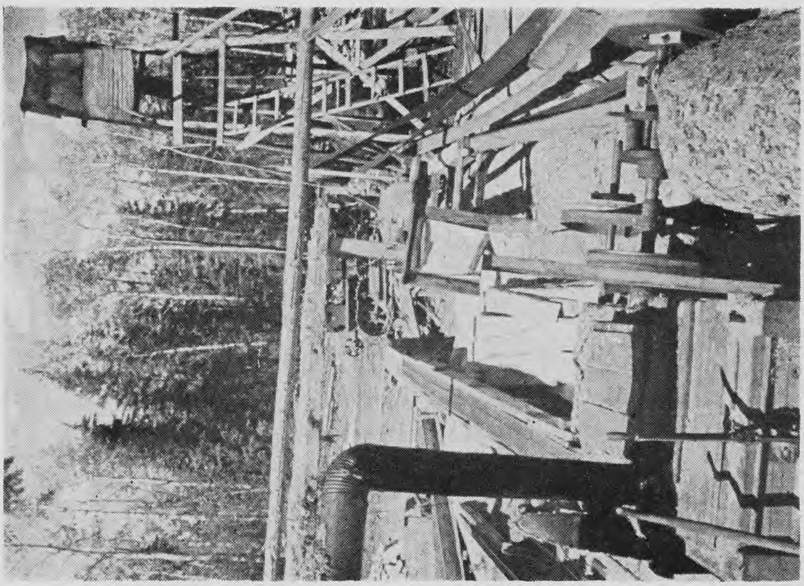
The struggle between the two fur companies led to the further building of rival posts over a wider area; thus adding to the knowledge of the West. In 1791, Thomas Frobisher built a fort at Ile a la Crosse for the North-West Company, and this is the second oldest settlement in Saskatchewan. Of particular interest to the present area is the work of William Tomison of the Hudson's Bay Company who built Hudson's House in 1779. This post was located in the present Nisbet Forest Reserve about 30 miles west of Prince Albert. In 1786 he established Manchester House, a post on an island at the junction of the Big Gully and the North Saskatchewan.

Another important development is indicated by the surveys conducted by Turnor, Fidler and David Thompson, which marked the beginning of our accurate geographical knowledge of the present area. Fidler established Essex House on Green Lake and Bolsover House on Meadow Lake in 1799, and also surveyed the Beaver River.

Agriculture in the west had its beginning in the gardens at the fur trading posts. The first garden in Saskatchewan was established

PLATE 7

Fishing on Little Bear Lake. Northern lakes provide excellent fishing, both for sport and as a commercial enterprise.



Lumber Mill, Big River. Lumber is an important product of the Northern Forest area.

by the French between 1753-56, on the river flat near La Corne's Fort.

In 1821 the struggle for the fur trade came to an end with the amalgamation of the rival companies under the name of the Hudson's Bay Company. Between that date and 1870, when the Dominion Government purchased the regions of Western Canada which were administered by the Company, the fur trade gradually declined, and lumbering and agriculture grew in importance. The first sawmill was erected at Ile a la Crosse in 1860 to fill local needs. Prince Albert became the main lumbering centre in 1878, the present city having been settled in 1866 by a group of people led by the Reverend James Nisbet, whose name is perpetuated in the Nisbet Forest Reserve.

The building of the Canadian Pacific main line in 1885 and the armed uprising of the Metis and Indians in the same year, as they saw their lands being occupied by the white settlers, are important events in the history of Saskatchewan. The surveyed area has several interesting associations with the uprising, including the evacuation of Fort Pitt by the North-West Mounted Police under the command of Francis Dickens, a son of the famous novelist. This evacuation was safely accomplished in the presence of a large force of hostile Crees led by Big Bear. There was also a clash between troops and Indians near Frenchman Butte. The Indians were later scattered and Big Bear captured after a long chase through the area, extending up to Loon Lake.

After 1885, agricultural settlement developed rapidly in the prairie section of the Province, where more railway lines were built and land could be broken with comparative ease. Development was slower in the northern section, and at Prince Albert, Green Lake, and Meadow Lake ranching was carried on for some years before arable agriculture was established. The area around Lloydminster was settled by the Barr Colonists around 1903-04.

A great increase in settlement took place between 1930 and 1940. This was due to the influx of settlers from the drought-stricken areas of Southern Saskatchewan. But while the new settlers escaped from the ravages of drought and soil drifting, they had to contend with heavy clearing, the absence of roads, and low agricultural prices. Improved economic conditions and a more rapid development of new lands took place during and after the Second World War. The demand for agricultural products, the use of modern power machinery to clear and break forest land, and the introduction of new and better crops have all contributed to this development. At the present time, the original forest cover is being rapidly cleared from the better agricultural soils, although the clearing may be regarded as excessive in some instances. The draining of wet areas and the indirect drainage effected by clearing, road construction and fires have also contributed to enlarging the area of arable land.

Further developments in the production of new varieties of crops, and in methods of maintaining and increasing soil fertility may be expected. The greater interest now taken by the general public and governments alike in the conservation of soil, water and forest resources may also affect the future of the surveyed area. In noting

PLATE 8

Emma Lake Provincial Park.

Main Beach, Lake Waskesiu, Prince Albert National Park.

the great changes that have occurred in the area, it is fitting that we should remember not only the pioneer settlers but also that earlier band of fur-trader explorers who set the stage of history for the events of our own time. The surveyed area and adjacent territory are the oldest sources of our recorded history, and at the same time the newest areas in our modern agricultural development.

Soil Classification

Soil Classification and Mapping.—Before the various soils of an area can be identified and separated in the field, some system of classification must be established to guide the mapper. On the other hand, the information secured during the field mapping may lead to the recognition of new types of soils, and these must be fitted into the system of classification. The characteristics of the various soils as classified and mapped in the field are also investigated by analyzing selected samples in the laboratory. Information on geology, physiography, climate, native vegetation, and agriculture is required for the Soil Report, together with detailed descriptions of representative soils. It is important to realize that a soil map covers only two dimensions, whereas a soil area has a third dimension as well—depth or thickness of profiles. Hence, while the soil map shows the location and extent of a particular soil unit, a full picture of the soil can only be obtained by reading the profile descriptions given in the Report.

The Soil Profile.—The formation of soil from the original geological deposit or soil parent material involves the following processes: the physical break-down of larger rock fragments; the chemical weathering or alteration of mineral particles; biological activities involving plant growth and soil micro-organisms; the formation of soil organic matter or humus; the movement of substances from the surface to the subsoil or vice-versa; and the development of soil structure. As a result of all these processes, differentiating features appear in the vertical section of the soil, to form what is known as the soil profile.

The classification and mapping of soils is based upon a study of the soil profile. The latter term is used to describe the succession of natural layers or horizons in the soil, extending from the surface down into the underlying geological material. The soil profile is examined by exposing a fresh road cut or by digging a pit large enough to give a complete view of the vertical section. In Saskatchewan the depth of the profile commonly ranges from two to six feet, but may be either shallower or deeper than this.

The features which distinguish the various layers or horizons of the profile are used in classifying and mapping the soil. These features are: the colour, structure, texture, thickness, and the chemical and physical composition of each horizon. In addition, the geological nature of the parent material and the topography of the site are also studied. Hence, a proper study of the soil profile requires both field and laboratory work.

For convenience, the main horizons of the profile, from the surface downwards, are designated by the letters A, B, C. The A

horizon generally coincides with what is known as the surface soil. It usually contains most of the soil organic matter and a large population of soil micro-organisms. The situation of the A horizon with respect to the surface brings it particularly under the influence of the climatic and vegetational factors. In addition, the surface of this horizon is directly affected by geological activities such as erosion, deposition, and weathering. Thus, biological, chemical, and physical processes are very active in the A horizon, and important changes may occur both in the orginal mineral particles and the plant residues.

The downward movement of water through the A horizon tends to remove part or all of the soluble salts, lime carbonate, and gypsum from this layer. Some of the mineral elements, fine clay particles, and organic matter may also be removed. This process is referred to as leaching, or eluviation. Where the A horizon is well developed, two or more sub-horizons may be distinguished. These are designated as A_1 and A_2, etc. The A_1 or upper section usually contains the greatest percentage of organic matter. The A_2 horizon, where present, is more severely leached than the A_1 and as a result is usually lighter in colour and lower in clay, organic matter and mineral nutrients. The A horizons of Saskatchewan soils are generally characterized by definite structural features. The A_1 is frequently granular to cloddy structured, while the A_2 is often platy. (The definitions of soil structural aggregates and of other terms used in soil science are given in Tables 21, 22, 25.)

The B horizon is situated immediately below the A and the materials leached out of the surface horizon are largely deposited and retained in the B, a process known as illuviation. Furthermore, chemical changes may result in the formation of additional clay within the profile. The B horizon is usually heavier in texture, more compact, and frequently contains greater quantities of lime (calcium-magnesium carbonate), gypsum (calcium sulphate) and other more soluble salts. Occasionally severely leached soils are encountered in which the soluble constituents (salts), lime, and gypsum have been completely removed from the B horizon.

As with the A horizon, the B is often subdivided into B_1, B_2, etc. Any definite differences in colour, structure, or other features may serve as the basis for the separation of sub-horizons. Quite often the B_1 is the heaviest and most compact layer, while the B_2 represents the zone of the highest concentration of lime carbonate. In deep profiles the lime concentration may occur in a B_3 horizon. It is customary to designate the horizon of lime concentration as B(ca), the symbol "ca" referring to the presence of free lime (calcium carbonate and magnesium carbonate).

The C horizon occupies the lower portion of the soil profile. It represents the geological deposit or parent material from which the true soil has developed. Some deposition from the A and B horizons and chemical and physical changes (weathering) may affect the upper section or C_1 horizon; the lower portion (C_2) is taken as the material lying below the point at which soil forming processes are active.

In profile descriptions reference is sometimes made to a D horizon. The D horizon represents a different geological deposit from that

forming the parent material or C horizon. Thus a stony boulder clay deposit underlying a smooth glacial lake clay would represent a D horizon below the clay profile. Where the soil profile is thin, the D horizon may exert an important influence on the overlying soil, affecting the movement and retention of water, lime and salts.

Soil Forming Factors.—The many kinds or types of soils found throughout the world, and also those occurring within one small locality, are due to variations in the major factors of soil formation. The major factors are:

1.—Climate.
2.—Vegetation and other living organisms (biological factor).
3.—Parent material (the parent geological deposit).
4.—Topography (relief, slope and aspect).
5.—Drainage.
6.—Stage of maturity (or time factor).

For mature soils, particularly those formed over broad areas, the influence of climate and its related biological factors dominates the formation of soils. Thus, world-wide regions or zones are recognized in which the majority of the soils reflect, in their profile features, the influence of the prevailing conditions of climate and vegetative growth. Within any one of these major zones many different soil profiles may occur which owe their distinctive character either to local modifications of the prevailing climate and vegetation or to the influences of the remaining soil forming factors—parent material, topography, drainage and stage of maturity.

The nature of the geological surface deposit has a very important influence upon the kind of soil that develops from it. The texture of the soil—whether it is sandy, loamy, or clayey, depends chiefly upon the character of the parent material. The total amounts of important mineral plant nutrients such as potash, phosphate, and calcium also depend largely upon the composition of the parent material.

The type of geological deposit is also related to the major physiographic features or land forms of an area, which are identified by differences in elevation, pattern of the drainage channels, general slope of the land, and surface irregularities. Local variations in relief and slope (topography) have important effects upon soil profile development. These effects are seen in the sequence of profiles from the highest site, such as a knoll or ridge, down to the lowest point, such as a slough or depression. The striking differences often observed between profiles occurring on different topographic positions are due chiefly to the effect of variations in slope and direction of slope on erosion, drainage, soil moisture efficiency, and vegetative growth. In some places differences in the profiles may be due, in part, to differences in the age of individual soils.

The effect of this time factor—or stage of maturity—may be illustrated by the differences between soils formed on recent flood plains of streams and those formed on older deposits on the upland. The upland soils have well developed profiles in which the various horizons are easily distinguished. The profiles of recent deposits are by comparison immature, since the deposit has not been subjected to

PLATE 9

Portion of road between Green Lake and Beauval. Travel is sometimes difficult in the more remote areas and the cost of transporting goods is high.

Highway between North Battleford and Meadow Lake. Good gravel highways now connect most marketing centres throughout the area.

the regional soil forming processes for sufficient time to permit the development of characteristic profile horizons.

The Classification of Saskatchewan Soils.—There are many ways of classifying soils and other natural bodies, depending upon the purpose of the classification. One of the simplest methods of classifying soils is based upon textural differences, whereby sands, sandy loams, loams, and clays are identified and used as mapping units. This was essentially the method followed in the first soil surveys of Saskatchewan. Although soil texture is a most important feature, it does not adequately express the soil profile, which is the basic unit of modern soil classification and mapping.

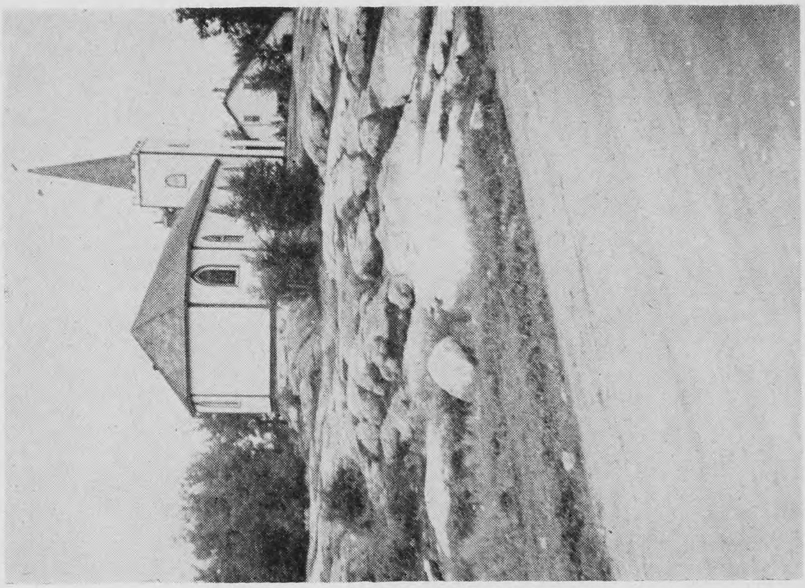
Since Pedology or soil science is a comparatively young branch of natural science, and since there are large areas of the earth that have not yet been mapped by soil scientists, there is at present no universally accepted and satisfactory system of soil classification. There are important types of soils forming world groups and concerning which there is general agreement among soil scientists. There are, however, many regional and local types of soils which have not yet been correlated satisfactorily with recognized world groups.

In classifying Saskatchewan soils, the Soil Survey has identified certain types of soil profiles which represent examples of soils found in other parts of the world. The Saskatchewan varieties of these soils and their arrangement into classification and mapping units are shown in Tables 6 and 7.

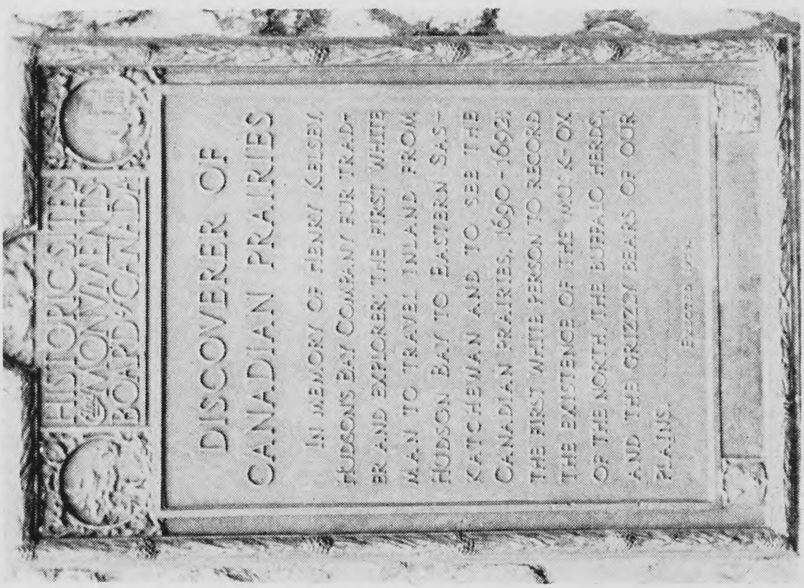
Referring to Table 6, the zonal soils represent Saskatchewan varieties of recognized world zonal soils, and as such are of direct interest to soil scientists in other regions. The recognition of zonal profiles also permits a broad grouping of Saskatchewan soils into major zones which can be shown on a soil map.

Within each zone all the soil profiles occurring on similar parent materials form a soil association. Thus the association is the basis for recognizing differences in the geological parent material factor. In Saskatchewan a more restricted definition of the soil association has been adopted, in which the profiles of a given soil association must belong to one zone, in addition to having a similar parent material. Thus, the Saskatchewan soil association represents a segment or section of the complete soil association or catena. The reason for restricting the association to soils belonging to one zone is to make the association a true classification unit as well as a mapping unit. Thus, in the Oxbow Association, all of the member profiles are black soils developed on similar parent materials. The locally occurring depression podzols and meadow soils are not black soils nor are they necessarily found on the Oxbow type of parent material. It is probable, however, that a new term should be established to cover this restrictive definition of the soil association, in order to avoid confusion with the definition adopted by the National Soil Survey Committee. It should be pointed out that the Saskatchewan definition was used in Soil Survey Report No. 12, which was published before the first meeting of the National Committee. Hence, the definition is used in the present Report in order to achieve uniformity with the No. 12 Report.

PLATE 10



Mission Church in Northern Saskatchewan. Missionaries, like the fur-traders, were explorers and pioneers of Western Canada.



Inscription to Henry Kelsey, fur-trader and explorer, erected at The Pas, Manitoba.

For those who may desire to make a further study of soil formation and classification, a list of suggested references is given below.*

TABLE 6.—KEY TO CLASSIFICATION OF SASKATCHEWAN SOILS

1. **Zonal Soil Profiles**	Profiles separated on differences in the colours of the surface horizons and other features due to the influence of the regional factors of climate and vegetation. Saskatchewan zonal soils include Brown, Dark Brown, Black, Black-Grey Podzolic (Degraded Black), and Grey Podzolic.
2. **Soil Association (Catena) Profiles**	A group of related soils occurring in close association and developed on similar parent material deposits. In any one zone, a Soil Association is established for the soils occurring on each type of parent material. In the present survey an association consists of profiles belonging to the same zone.
3. **Soil Member (Series) Profiles**	The individual types of profiles forming an Association, separated from each other on the basis of profile differences which result from local variations in topography, drainage, and stage of maturity. In most instances the member profiles represent recognized genetic soil types (World Group profiles). The principal member profiles of the present surveyed area are listed in Table 7.
4. **Soil Textural Classes**	Any soil separated on the basis of differences in soil texture (clay, silt, and sand content). In mapping, textural separations are most often applied to the surface horizons, although the textures of all the horizons are determined as well. Definitions of textural classes are given in Tables 21 and 22.
5. **Topographic Classes**	These are mapping units, representing variations in relief and slope that are significant to land use and to the recognition of an area in the field. A classification of topography is given in Table 23.
6. **Stony and Gravelley Classes**	These are mapping units, representing degrees of stoniness or the frequency of gravelly subsoils respectively, which are significant to land use. Definitions of stony and gravelly classes are given in Tables 22 and 24.

TABLE 7.—PRINCIPAL GENETIC SOIL PROFILES OF THE SURVEYED AREA, FORMING RECOGNIZED MEMBERS OF THE VARIOUS SOIL ASSOCIATIONS

1.—**Black Hard Columnar (Prismatic or Alkali-structured) Profile.**—Black, granular-cloddy A horizon. Lime-free, well developed columnar B_1, breaking to cloddy granular structure. Light grey, friable B(ca)—the zone of lime carbonate accumulation.

2.—**Black Solonetz Profile.**—Black, cloddy to platy structured A horizon, showing faint leaching; sometimes thin, greyish A_2 horizon present. Dark brown, hard, round-topped columnar B_1 horizon, breaking to hard cubic or angular fragmental aggregates. Lime carbonate present in lower B horizons. Soluble salts may also be present.

3.—**Black Solodized-Solonetz Profile.**—Black, cloddy-platy A_1 horizon, crushing to dark grey. Dark greyish-brown, thick platy A_2; thin, light grey, platy A_3. Dark brown, round-topped columnar B_1, heavy textured, compact and impervious. Light coloured, calcareous-saline, less compact lower B horizons.

*"The Great Soil Groups of the World," K. D. Glinka, published by Edwards Brothers, Inc., Ann Arbor, Michigan, 1927.
"Soils," G. W. Robinson, Murby and Company, London, 3rd Ed., 1949.
"Soils and Men," Yearbook of Agriculture, U.S.D.A., Washington, 1938.
"Pedology," J. S. Joffe, Rutgers University Press, New Brunswick, New Jersey, U.S.A., 2nd Ed., 1949.

4.—**Black Solod Profile.**—Black, cloddy-granular A_1 horizon, thick, brownish-grey columnar A_2, breaking into thick plate-like segments. Grey, platy A_3 horizon. Brownish, thin columnar B_1 horizon, sometimes with remnants of former round-topped structure; light coloured calcareous lower B horizons, which may also contain soluble salts.

5.—**Black Saline Profile.**—Black to greyish-black, friable granular A horizon, greyish, loose "puffy" B horizons with a high content of soluble salts, which concentrate at varying depths in the profile. When dry, salt crusts appear on exposed soil. Mottled, poorly drained, calcareous-saline lower subsoil.

6.—**Black High-Lime Profile.**—Black to dark grey, friable, granular to platy A_1 horizon, containing lime carbonate. Light greyish, very friable, highly calcareous B(ca) and C horizons.

7.—**Black Calcareous Columnar Profile.**—Black to dark grey, friable, granular A_1 horizon. Light brown to greyish-brown, thin, weakly developed, columnar B_1. Lime carbonate present in B_1 and frequently in lower A horizon. Light greyish, friable B(ca) and C horizons.

8.—**Dark Grey Calcareous (Wooded) Profile.**—Thick, dark grey, weakly platy to granular structured A_1; a medium grey, platy A_2 may be present. Dark greyish-brown, cloddy B_1, containing lime carbonate. Light coloured B(ca) and C horizons. Lime carbonate may be present in the A horizons or slight leaching may have removed the lime from the A and upper B horizons. The hard, compact, B horizon characteristic of degraded black soils is absent.

9.—**Black-Grey Podzolic (Degraded Black) Profile.**—Dark grey to dark grey-brown, granular-platy A_1. Greyish-brown to light brownish-grey, platy A_2. Brown to grey-brown, columnar to nutty B_1 horizon, hard and compact, free of lime carbonate. Yellow-brown, massive to large blocky B_2, less compact than B_1, occurs in deeper profiles. Light coloured B(ca) horizon of lime accumulation below. In heavy clay profiles a "shotty" granular A horizon may occur.

10.—**Black-Grey Podzolic-Solonetzic Profile.**—A_1 and A_2 horizons similar to Degraded Black. Very dark brown, hard columnar B_1, often round-topped, breaking to nutty or angular fragmental aggregates, free of lime carbonate. Lime carbonate (and often salts) present in lighter coloured lower B horizons.

11.—**Grey Podzolic Profile.**—Thin organic layer (A_0), unless destroyed by fire. Thin or absent dark-brownish A_1. Light brownish-grey to nearly white, highly leached, platy A_2. Brown to dark grey-brown, heavy textured, lime-free B_1, coarse granular to nutty and hard fragmental structure. Lighter brown or yellowish-brown B_2, somewhat less compact. Lime carbonate may be present but is frequently not encountered above the upper parent material (C_1 horizon).

12.—**Podzolized Sand Profile.**—Light grey to very light brownish-grey, loose structureless A_2 horizon, when dry may show weak platy structure. (A_1 horizon very thin or absent.) Loose to slightly compacted, reddish-brown to brown B_1 horizon. Yellow-brown, friable-massive B_2. No lime carbonate.

13.—**Brownish-Grey Podzolic.**—Dark grey to grey, loose-granular A_1, frequently occurring as a mixed A_0-A_1 horizon. A_2 pale brown to brownish-grey, thick platy structure, crushing to loose powdery condition. Brown, moderately compact, irregular-cloddy to granular structured B_1. Yellow brown, massive, less compact B_2. Lime carbonate may be present in B_3 but usually occurs only in parent material (C_1 horizon).

14.—**Podzolic-Solonetzic Profile.**—A_0 to A_2 horizons as in Grey Podzolic Profile Light Grey, platy A_3 on round-topped solonetzic B_1. Like the Degraded Black Podzolic-Solonetzic Profile, this appears to represent the podzol type of soil formation on a former solonetzic profile.

15.—**Depression Podzol Profile.**—Thick, greyish A_2 with rusty streaks and platy structure. Very dark coloured, waxy, heavy textured B_1. Poorly drained, mottled and sticky lower horizons (gley-like). Occurs in upland depressions.

16.—**Peat Podzol Profile.**—Organic (peaty) surface horizon, over grey, leached (podzolized) mineral A_2 horizon. Mottled sticky lower horizons (gley-like).

17.—**Meadow Profile.**—Dark A horizon high in organic matter. Greyish-mottled, wet, poorly drained subsoils, usually calcareous and sometimes saline.

18.—**Organic-Mineral (Shallow Peat) Profile.**—Surface peaty horizon consisting of raw and partially decomposed plant material. Dark grey mineral A_1 below. Wet, poorly drained, mottled greyish B horizon, usually calcareous.

19.—**Organic (Deep Peat or Bog) Profile.**—Thick raw peaty surface horizon. Partially decomposed organic horizons below, whose characters vary with degree of decomposition and the type of plant material. Wet and poorly drained throughout. Free lime carbonate generally absent from true organic layers, but may occur in underlying mineral material (D horizon).

20.—**Recent Alluvium Profile.**—Usually a thin A_1 horizon, dark in colour and granular structured. Lower horizons dark grey to light grey and yellowish, often forming definite layers which reflect deposition by water rather than true soil profile features.

21.—**"Dry" Sand Profile.**—Very slight to no A_1 development. Loose sand deposits, regarded as weakly developed soils.

22.—**Eroded (Truncated) Profile.**—Shallow soils of steep slopes and escarpments, with thin profiles, usually lacking one or more horizons common to regional upland soils.

The Association Member represents one of the recognized profiles belonging to a Soil Association. As indicated in Table 7, each Member profile is recognized by its distinctive morphology—the colour, thickness, structure, texture, composition, etc., of the constituent horizons of the profile. The majority of the Member profiles established in Saskatchewan consist of genetic soil profiles representing world-wide types of soil formation. Hence, while a Member profile of a given Association may represent a local area in Saskatchewan, it may also represent an example of a recognized world group of soils. In some instances, Member profiles represent transitions or gradations between two recognized genetic types, as in the Complex Podzolic-Solonetzic profile. Similarly, local Member profiles representing several stages of poor soil drainage may be recognized between the well-drained upland and the undrained basin or depression. These and other local variations in the Member profiles can only be separated on a very detailed map.

Textural, Topographic and Stony and Gravelly classes represent additional elements of the classification and mapping system which are of more local importance. Variations in texture and in the other units mentioned above are of particular concern to the soil surveyor in his task of mapping those features directly affecting the use of the soil. Soil texture is closely related to the nature of the geological parent material and also to the type of soil profile which has developed. Soil texture is of special importance in estimating the relative ability of different soils to retain water and withstand drought.

The classification of topography involves the recognition of important variations in surface features. These include steepness of slope, which is related to differences in relief or elevation between the highest and lowest points; and the shape and frequency of various slopes, which determine the comparative roughness of the surface.

The topographical features encountered in the surveyed area include ranges in slope from 0% to over 30%, and variations in surface conditions ranging from smooth unbroken land to rough, irregular land marked by a succession of ridges, steep slopes and numerous local depressions.

The complete list of topographic classes used by the Soil Survey cannot be shown on the reconnaissance soil map. Instead, the more important types of topography have been grouped in six classes, and these are indicated by appropriate symbols on the published map.

The six classes of topography are listed below:

1.—Depressional to flat (chiefly 0% slopes).

2.—Very gently sloping to gently undulating (0.5% to 5% slopes, of low frequency).*

3.—Roughly undulating (2% to 5% slopes, of high frequency).

4.—Gently to moderately rolling (6% to 15% slopes).

5.—Areas of mixed undulating and rolling topography.

6.—Strongly rolling to hilly (16% to over 30% slopes).

Depressional topography is associated with undrained and very poorly drained lands, such as creek and valley bottoms, sloughs, and meadow-bog areas.

The sloping to undulating class includes the most desirable topography for agricultural use. The slopes are smooth, and unbroken by steep ridges or deep depressions. The best land of this class offers little difficulty to cultivation and permits maximum retention of soil moisture without either flooding or serious loss by run-off.

Roughly undulating land is characterized by numerous low ridges and knolls, short slopes and lower depressions (high frequency topography). As a result, the surface is very uneven or "choppy" and there is often a high proportion of the low, poorly drained land which in wet seasons is non-arable.

Gently to moderately rolling land is characterized by a succession of ridges and knolls, separated by lower areas that frequently contain poorly drained depressions or sloughs. The slopes are both steeper and more frequent than those of sloping to undulating land of Class 2. Rolling areas are distinctly inferior in ease of cultivation, retention of moisture, and soil uniformity. Moderately rolling areas approach the point where increasing steepness of slope and rougher surface prevent the cultivation of large fields.

Areas mapped in mixed undulating and rolling topography consist of local areas of both of these classes which cannot be shown separately on a reconnaissance map.

Strongly rolling to hilly areas are so rough and steep that cultivation becomes impracticable. In settled districts such lands are used chiefly for pasture. Small areas of better topography occur locally in hilly belts, and these are frequently cultivated. In general, however, this class has a low agricultural value.

The relationship between the topographic classes used in the present survey and those adopted by the National Soil Survey Committee is shown in Table 23.

Stony and gravelly classes are used to indicate soil areas in which stones or gravelly subsoils respectively are sufficiently numerous to adversely affect the agricultural use of the land. Excessively stony land, where indicated in the map, represents land that is too stony to permit cultivation.

*Frequency refers to the number of "rolls" or undulations occurring within a given horizontal distance. Thus, the number of ridges or knolls occurring per mile gives an indication of the comparative roughness of the surface. Where the topography is of high frequency there are more ridges per mile and the slopes are more numerous and shorter than in low frequency topography.

The Black Soils

The Black Soils occurring in the present area are represented by the following Associations:

Oxbow	Onion Lake	Blaine Lake
Waseca	Whitesand	Canora
Lloydminster	Meota	Meadow Lake

The Lloydminster, Onion Lake, and Meadow Lake soils represent new Associations not hitherto mapped in Saskatchewan.

Most of the Black Soils are found in the Parkland Prairie between Turtleford, Lloydminster and Edam. The Meadow Lake soils are restricted to a small area around the town of Meadow Lake. Some of the Oxbow and Whitesand soils occur along the southern border of the area. Oxbow soils mapped as a complex with Whitewood soils occur just north of Glaslyn. Small areas of Black Soils also occur in the Shellbrook and Prince Albert districts where they form small scattered islands among the wooded podzolic and calcareous soils.

The typical location for the Black Soils is, however, the main Parkland Prairie section of the Grassland Region. The term "Parkland" is given to the section because of the presence of small clumps or "bluffs" of aspen and willow among the open grassland areas. This type of landscape affords a sharp contrast to the bare open prairie sections to the south and the solid forest cover to the north.

Despite the invasion of trees, the true Black Soils have developed under a grassland vegetation. The dark surface colour of the soils and their high content of organic matter and nitrogen are evidence of a long period of soil formation under a grassland vegetative cover. The Black Soil Associations are discussed individually in the following pages. Some of the profile relationships occurring in this zone are illustrated in Figure 5.

OXBOW ASSOCIATION

Description.—The Oxbow Association consists of medium (loamy) textured black soils, developed on undifferentiated boulder clay deposits.* In the present area, the Oxbow soils are relatively unimportant, only about 27,000 acres having been mapped. These soils are found chiefly along the southern border of the area, between Glenbush and Edam. They are also mapped north of Glaslyn. The Oxbow soils are the most extensive of the black soils south of Township 48, where they occupy nearly seven million acres.

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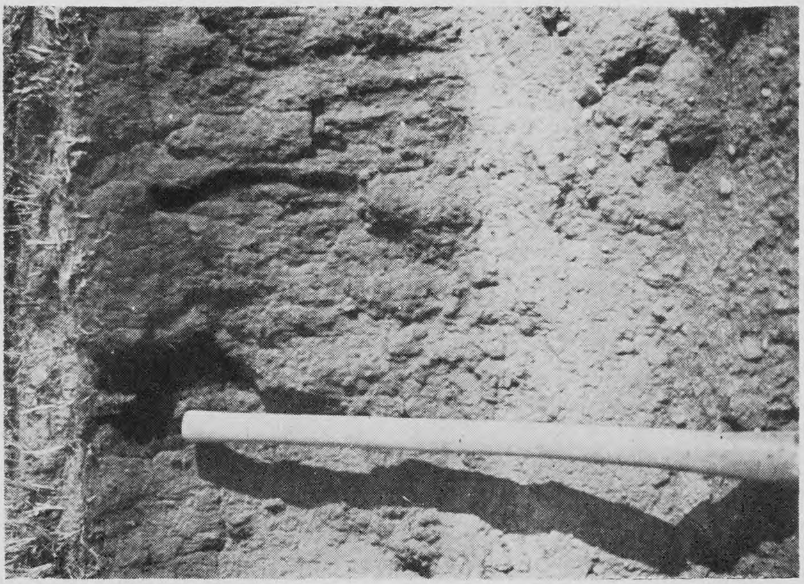
*The term "undifferentiated" is used to designate large areas of fairly uniform glacial till or boulder clay on which soil associations representing Brown, Dark Brown, Black, Black-Grey and Grey (Podzolic) soils have developed. Altogether; about 27,000,000 acres have been classified as undifferentiated boulder clay, forming the parent materials of the Haverhill, Weyburn, Oxbow, Whitewood and Waitville Associations. It is probable that more detailed studies of the soils and geological deposits will permit the separation of this large area of undifferentiated boulder clay into more specific types of till and lead to the recognition of new soil associations. For the present, the term "undifferentiated" denotes calcareous moraine and ground-moraine deposits, of medium texture, medium grey colour, frequently with a yellowish tinge, and massive to faintly laminated structure. Compared with the parent material of the Waseca, Horsehead and Loon River soils, the undifferentiated boulder clay is lighter in colour, much more friable and considerably higher in lime carbonate.

PLATE 11

Black soil profile—solonetzic member of Meadow Lake Association.



Black soil profile—hard columnar member of Oxbow Association.

The soil landscape of the Oxbow Association is characterized by a wavy type of topography, consisting of a succession of knolls, intermediate slopes and depressions. This sequence of surface features is typical of glaciated plains and is associated with soils formed on boulder clay deposits. The frequent occurrence of glacial stones and boulders is also a characteristic feature. In the present area, the Oxbow soils are largely associated with rough morainic upland or with undulating to rolling areas bordering deep coulees. Clumps or "bluffs" of aspen and willow intermixed with open grassland or dark coloured cultivated land are features of the Oxbow landscape. Patches of light grey limy soils occur on cultivated knolls and upper slopes, while greyish leached (depression podzol) soils occur around the margins of sloughs and in shallow upland depressions.

About one-third of the Oxbow soils are mapped on very gently sloping and undulating topography, and another third on hilly topography. The remainder include mixed areas of undulating-rolling topography and rolling topography. (See page 51 for definitions of topographic classes and ranges in slope and frequency.)

Surface drainage is adequate on the smoother types of topography, but may be excessive on the upper slopes of rolling and hilly areas. The depressions are undrained and form wet sloughs or ponds during periods when surface water accumulates. Internal or profile drainage is satisfactory for crop growth in most Oxbow soils, with the exception of poorly drained types bordering the depressions, and local soil areas where gravelly subsoils permit a rapid loss of water by percolation.

Glacial stones and boulders, varying from small (cobble) sized fragments of 1 to 3 inches up to boulders of 12 or more inches in diameter, are present in all Oxbow soils. The average stone classification of the more level Oxbow soils is moderately stony (S_2), with moderately to very stony classes (S_2 to S_3) associated with rolling lands. Local areas of excessively stony (S_4, non-arable) soils may occur on ridges and in eroded areas. (Definitions of the various classes of stony land are given in Table 24.)

Local patches of gravelly subsoils also occur in Oxbow soils, particularly in the light loams and in rolling to hilly areas.

The Oxbow soils are mapped as loam and light loam textures. Approximately two-thirds of the total area of Oxbow soils are mapped as loam. Local areas of clay loam may be encountered within the loam belts. The textural designations shown on the map represent the predominant texture or textures of a given soil area.

Soil member profiles of the Oxbow Association include the Hard Columnar, Poorly Drained Columnar, Solonetz, Solod, Calcareous Earth and Thin or Shallow Knoll types. The dominant member profile of the Oxbow Association is the Hard Columnar profile. This member occupies well drained positions ranging from nearly level to the intermediate slopes of rolling topography. Generalized descriptions of important Oxbow member profiles are given below:

Oxbow Hard Columnar Profile:

A_1 Horizon.—Very dark brown to nearly black, friable granular and soft cloddy structure at surface, cloddy below, (4" to 7" thick). The dark

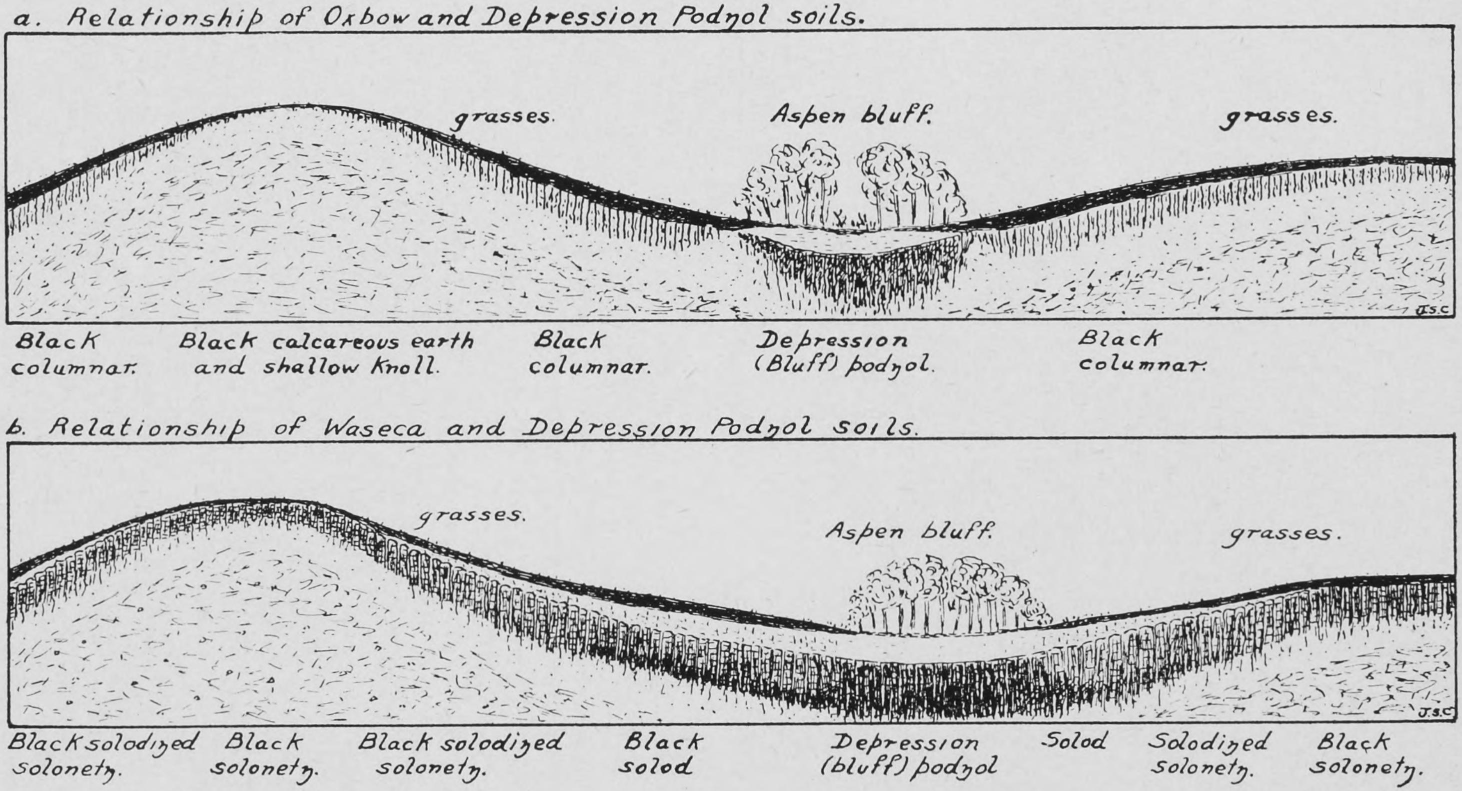


FIGURE 5

Profile Relationships in the Black Soil Zone.

surface colour gradually fades with depth, and in the deeper Oxbow profiles a dark greyish-brown cloddy A_2 horizon may be distinguished. (Definitions of soil structural aggregates are given in Table 25.)

B_1 Horizon.—Reddish-brown to dark brown, moderately hard columnar structure, (6″ to 10″ thick). The bottom of the B_1 horizon may be yellowish-brown or greyish-brown in colour, forming a transition to the lower B. Where this transitional layer is well developed it may be regarded as a B_2 horizon.

B(ca) Horizon.—Light grey to brownish-grey, massive structure but very friable, falling easily into fine granules. High content of lime carbonate (8″ to 18″ or more thick).

C Horizon.—Medium grey to faint yellow-grey, calcareous (limy) boulder clay, marked by spots and concretions of yellowish, rusty, and bluish-grey material and by light greyish streaks of lime carbonate and salts. Glacial stones, small stone fragments and gravel are common.

In low flat positions bordering sloughs or other depressions, the Oxbow soils show evidence of poor drainage, and frequently of accumulation of salts (salinization). The poorly drained Columnar member may be regarded as a transitional profile between the Columnar member and Meadow soils. It has a granular A_1 horizon (6″ to 10″ thick) of a very dark grey or mixed grey-black shade. The B_1 horizon is dark grey, mottled with rusty, yellowish and bluish-grey spots and streaks; the structure is irregular columnar and this horizon sometimes contains lime and soluble (alkali) salts. The B_2 horizon is yellowish-grey, mottled with various other colours and contains moderate quantities of lime and salts.

The Solonetz and Solod members usually occupy small local areas of slightly lower and flatter topographic positions within nearly level to gently undulating topography. The Solonetz member has a very dark brown to very dark grey cloddy A_1 horizon (3″ to 4″ thick). The A_2 horizon is dark grey to dark greyish-brown of cloddy-platy structure (2″ to 4″ thick). The B_1 horizon is very dark brown to dark reddish-brown, of hard columnar structure, more compact than the average B_1 and breaking to hard cubic and fragmental aggregates. Lime and salts are present in lower horizons.

The Solod profile is characterized by a leached greyish-brown, columnar-platy A_2 (6″ to 12″ thick) and a thin B_1 (2″ to 6″ thick).

The Calcareous Earth and Thin Knoll members occupy upper slopes and crests of knolls and ridges respectively. These profiles are, therefore, more frequently encountered on rolling to hilly topography. The Calcareous Earth member differs from the dominant Columnar member chiefly in possessing a weakly developed, soft, columnar structured B_1 horizon that contains lime carbonate. The B(ca) horizon usually yellowish-grey to light grey with a friable granular structure and a high content of lime carbonate.

The Thin Knoll profile has a dark brown to very dark brown A_1 horizon (2″ to 4″ thick). There may be a very thin grey-brown columnar B_1 horizon, or else a dark grey-brown transitional (A-B) horizon. The B(ca) horizon is encountered at 6″ to 8″ below the surface. Under cultivation, the thin A and B horizons become mixed and accelerated erosion may proceed to the stage where individual horizons cannot be distinguished. The cultivated surface will then consist of a whitish very limy soil, giving the light coloured knolls and ridges which are characteristic of cultivated Oxbow soils.

Associated with the tree-ringed sloughs or depressions are small local areas of Depression Podzol and wet Salinized Meadow profiles. Such soil areas are too small to be shown on the ordinary soil map.

The Oxbow soils have been mapped as mixed soils or complexes with Waseca, Whitesand and Whitewood soils. Oxbow soils are distinguished from Waseca soils by the fact that the latter consist chiefly of Solonetzic Member profiles which lack the well developed light coloured horizon of lime accumulation (B(ca) horizon). Oxbow soils have darker coloured surface horizons than the Whitewood soils. Whitesand soils can be distinguished by their coarse sandy and gravelly textures.

Agriculture.—Oxbow soils are in general highly fertile and productive. They are fairly high in organic matter and nitrogen and possess desirable structure. These statements apply particularly to Oxbow loam soils on nearly level to gently undulating topography. The best Oxbow loams are rated at 61 on the basis of relative suitability for grain production, mainly of wheat. The soil ratings are discussed in a later section of this Report, page 192.

Oxbow light loams of similar topography are rated considerably lower (49) than loams, since they are less uniform, lower in drought resistance and lower in potential fertility.

The greatest variation in the agricultural value of Oxbow soils is due to topography, and in some instances to the degree of stoniness. As the topography becomes steeper and rougher, the proportion of arable land decreases. More of the surface is occupied by sloughs and poorly drained soils surrounding them, and by thin, relatively droughty profiles of steep slopes and ridges. In rolling areas (gently to moderately rolling classes) Oxbow soils may be rated from 7 to 20 points lower than those on better topography. Strongly rolling to hilly areas are classified as non-arable. The slopes are so steep and the surface so broken that cultivation is not practicable. Also such areas are often very stony. Where cultivated fields are observed within areas mapped as strongly rolling to hilly Oxbow soil, it will usually be found that the cultivated land represents a local area of somewhat better topography.

Oxbow soils are subject to slight wind erosion, and sometimes moderately severe drifting may occur on light loam types. Slight to severe water erosion may occur on long slopes and in rolling to hilly areas. Sheet erosion tends to wash away the thin dark surface horizon from thin knoll profiles, with the result that cultivated fields are characterized by light greyish colored knolls and upper slopes. Shallow gullies may also develop on lower slopes.

The Oxbow soils of the present surveyed area occupy a larger proportion of rough topography than is found in the main Oxbow belts of south-eastern Saskatchewan. Oxbow soils of the present area are also situated in an area more subject to frost hazards.

Cultivated Oxbow soils are used principally for wheat production although noticeable acreages of coarse grains are also grown.

WASECA ASSOCIATION

Description.—The Waseca Association consists of medium textured black solonetzic soils developed on morainic deposits composed of a mixture of northern boulder clay and local till derived from underlying Cretaceous sediments. Geologically the Waseca soils occupy areas of thin boulder clay overlying Cretaceous bedrock, and in the present area occupy most of the Paradise Hill-Lloydminster Upland and adjacent areas on the Turtleford Dissected Plain. Approximately 360,000 acres were mapped in the Waseca Association, representing 5.7 per cent. of the total area surveyed. About 200,000 acres of Waseca soils were mapped south of Township 48, in the area covered by Report No. 12.

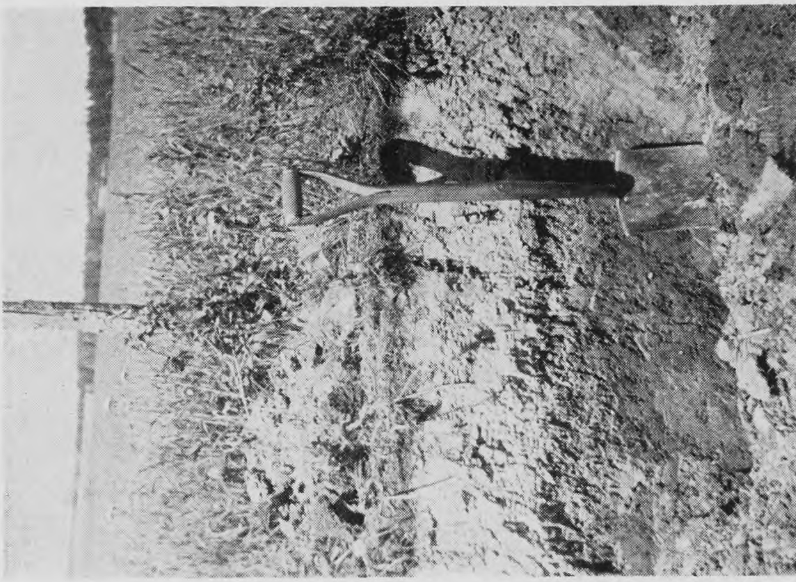
The soil landscape of the Waseca Association is characterized by a rough surface, varying from undulating ground moraine to strongly rolling and hilly morainic upland. The undulating areas are characterized by numerous low ridges with very steep sides. Numerous sloughs and greyish spots of depression podzols occur among the dark grey cultivated soils. The absence of a uniform light grey lime layer is a distinctive feature. Clumps or bluffs of aspen and willow are common. The hilly areas contain considerable native grassland, with clumps of trees occupying the more moist lower sites on southern slopes, and extending higher up on the cooler northern slopes. The hilly areas, while they have quite steep slopes, are less broken than typical hilly moraines, and in general are less stony. It is considered that the major features of the Waseca rolling to hilly upland are a reflection of the underlying bedrock surface, which was only slightly modified by glaciation.

Nearly one-half of the Waseca soils are mapped on rolling to hilly topography and another 100,000 acres as mixed areas of undulating and rolling topography or as roughly undulating. The low sharp ridges already referred to are most noticeable in the two latter classes. Many of these ridges are cultivated, but others are too steep. Where steep ridges and associated sloughs are numerous the amount of waste land per farm is high. The best topography is classed as gently undulating and is found in local areas of resorted till representing a complex of Waseca and Lloydminster soils.

Surface drainage is satisfactory on the undulating uplands, but excessive on the steep ridges and on the slopes of the hilly areas. Poor to very poor surface drainage is found on level to depressional lowlands. Internal or soil profile drainage is adequate in the dominant solonetz and solod profiles on nearly level to undulating topography. Where solodized-solonetz profiles occur, internal drainage is seriously restricted in the heavy compact B horizon. Very poor soil drainage is associated with the undrained sloughs, ponds and depression podzols associated with Waseca soils.

Glacial stones are common to all Waseca soils. Moderately stony (S_2) conditions predominate. Slightly stony (S_1) conditions are associated with the better undulating areas, and local spots of very stony soils (S_3) are encountered in rolling areas and where Waseca soils are mixed with Whitesand soils. Gravelly-sandy pockets occur locally on the ridges, and cobbly streaks occur in the subsoils where the till has been modified by water action.

PLATE 12



Grey soil profile—podzolic-solonetzic member of the Garrick Association.

Degraded black soil profile—slightly degraded member of the Makwa Association.

Waseca soils include clay loam, loam and light loam textures. Over two-thirds of the Waseca soils of the present area are mapped as loam, and Waseca loam and clay loam together make up about three-quarters of the total acreage. Clay loam types are confined to the rolling and hilly uplands, while most of the light loam is found in undulating and mixed undulating-gently rolling areas.

The Waseca Association consists chiefly of member profiles belonging to the Solonetzic group of soils. Solonetz and Solod profiles predominate in the well drained positions between the knoll and the depression. Thin Columnar solonetz-like profiles occur on the ridges and hill-tops and poorly drained Salinized-Solonetz and Podzolic-Solonetz border the lowland depressions.

Generalized descriptions of important Waseca profiles are given below:

Waseca Solonetz Profile:

A_1 Horizon.—Black, crushing to very dark grey. Small cloddy-columnar structure (4″ to 7″ thick). A very thin greyish A_2 horizon may be distinguished at the base of the A_1.

B_1 Horizon.—Dark grey-brown to very dark brown; compact, hard columnar structure, sometimes showing faint round-top development. This horizon breaks into hard cubic aggregates or into hard angular fragments (6″ to 8″ thick).

B_2 Horizon.—Yellow-brown; columnar structure (4″ to 8″ thick).

B_3 Horizon.—Yellowish-grey to grey-brown, streaked with lighter coloured lime carbonate, instead of the uniform light grey colour of the typical horizon of lime accumulation. It may be difficult to separate the Waseca B_3 horizon from the upper parent material (C_1) (8″ to 15″ thick).

C_2 Horizon.—Medium to dark grey boulder clay, crushing to dull yellowish-brown. This deposit is hard and compact, and very difficult to dig when dry. The structure is massive to laminated, breaking readily into small columnar-like aggregates, and these break into hard cubic and angular fragments. Small pieces of lime-free grey and dark grey shale and shaly clay may be encountered. Small stones and occasional small boulders occur in the till. Lime carbonate present in streaks and spots. Where the deposit has apparently been re-worked by water action the till is lighter coloured and somewhat less compact. The latter modification is common in the Waseca soils occurring in the Turtleford area.

The Waseca Solod profile has a dark grey to very dark grey A_1 horizon, with a cloddy-platy structure (4″ to 6″ thick). The A_2 horizon is brownish-grey, thick platy (2″ thick). The A_3 horizon is greyish-brown, and has a columnar structure which breaks into thick flat-topped segments or plate-like aggregates characteristically darker on the under side (4″ to 8″ thick). The B_1 horizon is reddish-brown to very dark brown, of compact columnar structure which breaks into hard fragmental aggregates (6″ to 8″ thick). This horizon is underlain by the B_3 or transitional B_3-C_1 horizon already described. The Solod member of the Waseca is thinner than the solod profiles encountered in the Robsart and Estevan Associations. The Waseca type seems morphologically to represent a transition between the solodized-solonetz and solod profiles.

Thick Hard Columnar profiles previously described under Waseca may more logically be regarded as members of the Lloydminster Association, which was not established when the No. 12 Report was issued. For the Waseca Association, a more typical

columnar profile is that occurring on ridges and upper slopes. Here the profile is relatively thin and is characterized by a hard columnar structure extending from the A into the B_1 horizon, and breaking into tough, hard, cubic aggregates. This profile may be regarded as a solonetz-like member.

The salinized-solonetz profile has a darker A_1 horizon than the upland solonetz, and the B_1 horizon is mottled with rusty spots and streaks. The lower B and the C horizons contain soluble "alkali" salts as well as lime carbonate.

The variations in the Waseca profiles resulting from differing degrees of solonetzic soil development are further complicated by the effects of podzolic leaching associated with the trees surrounding the wet depressions or sloughs. In some instances, it would appear that the original solonetzic profile has been modified by the later effects of podzolization. The resultant profile has a greyish platy A_1 horizon, a light grey, strongly leached, platy to structureless A_2 and a very dark compact, solonetzic-columnar B_1 horizon.

Waseca soils are mapped as complexes or mixtures with Whitewood, Onion Lake, Whitesand and Lloydminster soils respectively. Waseca soils are distinguished from Whitewood soils by the fact that the latter have thick greyish podzolized A_2 horizons. Onion Lake soils are heavier textured and typically show more evidence of solodization—the presence of well developed round-topped B_1 horizons and the associated light coloured A_3 and A_2 horizons above. Whitesand soils are coarse textured and in general have columnar B_1 horizons. The Lloydminster soils may be regarded as deep Waseca Solonetz and Solonetz-like Columnar profiles, developed on nearly level resorted boulder clay.

Agriculture.—The well drained undulating loams and the gently rolling clay loams are the best agricultural soils of the Waseca Association. These soils are fertile and are usually not very stony. Occasional wet sloughs surrounded by willows are the chief obstruction to cultivation. Depression podzols occupying slight upland depressions are cultivated but in wet years seeding may be delayed.

Waseca soils of roughly undulating to moderately rolling topography are associated with more sloughs and steep ridges and hence with more non-arable land. Additional land is being broken in the rolling areas north of the Big Gully, where the surface, although sloping, is not excessively rough and broken. The use of modern power machinery has facilitated breaking such areas.

Wind erosion is not a serious problem on Waseca soils, but water erosion, particularly in rolling areas, is becoming more noticeable. Rills and shallow gullies are most in evidence but considerable sheet erosion must have occurred also. It is difficult to recognize sheet erosion on Waseca soils, since the uniform lime carbonate layer is absent, and the knolls and ridges do not present the whitish appearance associated with cultivated Oxbow, Blaine Lake, and other more calcareous soils.

Wheat is the most important single crop on Waseca soils but considerable oats and some barley are also produced. Frost is a

definite hazard, or at least a threat, in most seasons. Some alfalfa and grass are produced, principally in the general Lloydminster area. North of the Big Gully water is difficult to obtain and this is a definite handicap to the development of a more diversified agriculture.

Waseca soils are rated slightly below the Oxbow types. The best rating for Waseca loam is 57 and for the clay loam 63. The latter rating will rarely occur since the clay loam occurs on rolling topography, which is subject to deductions of up to 20 points.

LLOYDMINSTER ASSOCIATION

Description.—The Lloydminster Association consists of thick black solonetzic loamy soils on modified (resorted) boulder clay overlying Cretaceous bedrock. The term "thick" or "deep" black refers to the thickness of the A_1 horizons. Thick black soils usually possess from 8" to 12" or more of a very dark A_1 horizon, whereas ordinary or thin black soils, such as the Waseca and Oxbow, are characterized by A_1 horizons of 4" to 7" thick. While the above separation may appear to be somewhat arbitrary, it is based on features that can be recognized in the soil and is also of agricultural significance. The thick black soils are associated with the more humid portions of the black soil zone or, where they occur locally, with topographic positions which favour the maximum accumulation of soil organic matter. The thick black soils contain more organic matter and nitrogen than thin black soils of similar texture and topographic position.

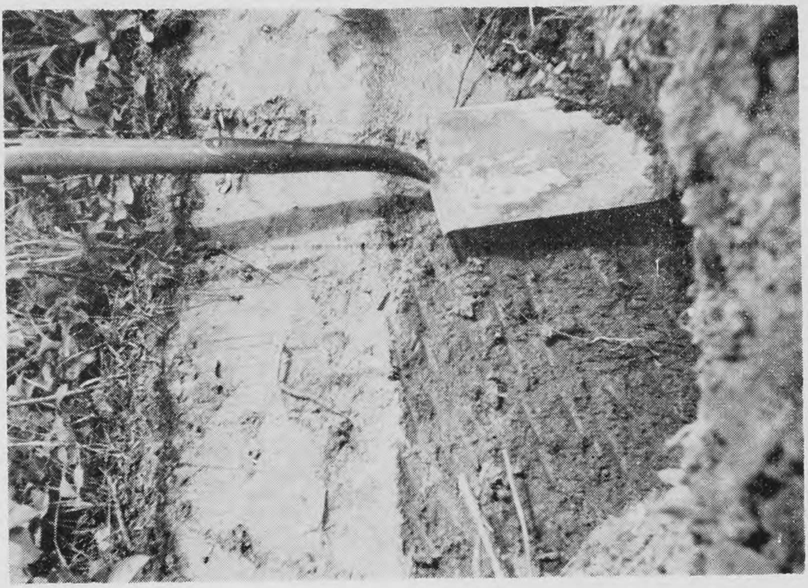
The Lloydminster Association was established in co-operation with the Alberta Soil Survey, since these soils occur chiefly in Alberta. In Saskatchewan they occupy only about 12,000 acres, mostly in the vicinity of Lloydminster. The nearly level to gently undulating land on which the Lloydminster soils are found does not extend very far east of the town. Where the topography becomes slightly rougher, Waseca soils predominate with small local areas of Lloydminster soils occupying the lower and more level arable land. The occurrence of local areas of Lloydminster soils is indicated on the soil map by using a mixture of Lloydminster and Waseca Associations. Many smaller areas could not be indicated, but may be looked for in Waseca soil belts.

The soil landscape of the Lloydminster Association is characterized by nearly level to gently undulating topography, very dark grey cultivated soils (black when moist), relatively few stones, well developed farms, and a luxuriant growth of grass interspersed with thick clumps of aspen trees and shrubs. Aspen and willow surround wet marshy depressions and, when cultivated, the former wooded area shows the grey surface colour of the depression podzol.

Lloydminster soils occur on nearly level to gently undulating topography. Where rougher topography is indicated on the map, Lloydminster soils occur as a complex with Waseca soils, and the latter occupy the higher and rougher land.

Surface drainage is adequate on Lloydminster soils, with the exception of the flat areas bordering depressions. Internal profile drainage is good except in the poorly drained profiles associated with flat topography.

PLATE 13



Grey podzolic soil profile—well drained upland member of Dorintosh Association.

Grey podzolic soil profile—brownish-grey member of the Smeaton Association. The heavy boulder clay D horizon is exposed below the spade.

Glacial stones are present in Lloydminster soils, slightly stony (S_1) to moderately stony (S_2) conditions prevailing. Very stony soils are rarely if ever encountered and many of the stones are small. The Lloydminster soils are mapped as loam and light loam, about three-quarters of the total area being classified as loam.

The Lloydminster Association consists chiefly of solonetz and solonetz-like profiles which are deeper than those of the Waseca Association. Poorly drained members of the Lloydminster Association border the undrained depressions or sloughs.

Generalized descriptions of Lloydminster member profiles are given below:

Lloydminster Solonetz Profile:

A_1 Horizon.—Very dark greyish-brown; columnar-cloddy structure breaking to flat-topped segments (6″ to 8″ thick).

A_2 Horizon.—Brownish-grey; columnar structure, breaking into flat, thick, plate-like segments (4″ to 5″ thick).

B_1 Horizon.—Dark brown, sometimes faintly reddish-brown; hard columnar structure, breaking to hard cubic aggregates (6″ to 8″ thick).

B_2 Horizon.—Dark greyish-brown, columnar structure, breaking to hard cubic and angular fragmental aggregates; heavy textured, compact solonetzic horizon (8″ to 10″ thick).

B(ca) Horizon.—Grey, massive structure. Lime carbonate and salts present. Grades into upper parent material (8″ to 12″ thick).

C Horizon.—Dark grey, streaked with lighter grey, faintly laminated modified (resorted) boulder clay. Small glacial pebbles and occasional stones present. Moderate lime carbonate and salt content.

Lloydminster Hard Columnar or Solonetz-like Profile:

A_1 Horizon.—Black, friable cloddy-granular loam to light loam (8″ to 12″ thick).

B_1 Horizon.—Brown to dark brown, columnar structure (8″ to 10″ thick).

B_2 Horizon.—Yellow-brown, large blocky-columnar structure, compact (8″ to 12″ thick).

B(ca) Horizon.—Greyish, lime carbonate and salts present (8″ to 12″ thick).

C Horizon.—Parent material.

The poorly drained Lloydminster soils are usually solonetzic types with salty, mottled B horizons. These soils may be associated with depression podzols.

Lloydminster soils are mapped as complexes with Waseca and Meota soils respectively. In Lloydminster-Waseca areas, the Lloydminster soils occupy the nearly level to very gently undulating topographic positions, with Waseca soils occurring on higher and relatively rougher land. The mixed Lloydminster-Meota soils are of local occurrence along the south side of the Big Gully. Here the boulder clay has been partially covered by alluvial sandy deposits, on which Meota soils have developed.

Agriculture.—Lloydminster soils are very productive, due to their high content of organic matter and nitrogen, favourable topography, and location in a zone of high soil moisture efficiency. Erosion is not a serious factor in Lloydminster soil areas, nor are stones a handicap to cultivation.

Oats and wheat are the main crops grown on Lloydminster soils. The relatively cool, moist climate favours the production of oats and, in addition, the danger of frost makes oats a surer crop than wheat. Barley is also grown to a considerable extent; small areas of alfalfa and grasses are grown and observations indicate that these crops do very well. The Lloydminster soils are the best agricultural types in the Lloydminster district. The Lloydminster loam is rated at 68 and the light loam at 61.

ONION LAKE ASSOCIATION

Description.—The Onion Lake Association consists of heavy to medium textured black solonetzic soils developed on deposits derived from modified bedrock shales of Cretaceous age. These soils are mainly confined to the Paradise Hill-Lloydminster Upland, where they occupy about 22,000 acres as mapped. Small local areas of these soils may be encountered in Waseca soil areas, particularly north of the Big Gully. The Onion Lake soils have been correlated with a larger area of soils on sorted residual deposits and thin till over bedrock occurring in Alberta.

The term "modified" bedrock is used to indicate areas of bedrock that were thinly covered by glacial drift, so that the bulk of the soil forming material is considered to be derived from the underlying pre-glacial shales. These shales are soft, generally acid in reaction, and weather to form a sticky clay. The shales are also a source of "alkali" salts.

The soil landscape of the Onion Lake Association is characterized by rolling to hilly topography of a less "choppy" or irregular type than that associated with glacial morainic areas. Evidence of the underlying bedrock is seen in the dark heavy clay and shale fragments and the presence of alkali salts in exposed subsoils. Some of the upland areas are marked by the small eroded depressions ("burn-out" or "blow-out" pits) which characterize areas of solodized-solonetz soils. These depressions carry a thinner vegetative cover or crop than the non-eroded areas. The landscape of the Onion Lake soils is also characterized by parkland vegetation. The trees occupy northern slopes or other sites where conditions of moisture and shelter are favourable to tree growth, while grasses occupy the tops and southern slopes of hills and ridges. The low areas contain occasional lakes and more frequent shallow ponds or sloughs, in some places forming a chain along shallow coulees that appear to represent former drainage channels which have become blocked.

The topography of Onion Lake soils consists chiefly of gently rolling to hilly uplands, and local areas of flat-depressional lowland. There are a few small areas of undulating topography.

Surface drainage is somewhat excessive on the steep upper slopes of rolling areas, but satisfactory on lower slopes and on undulating lands. Poor to very poor drainage is associated with the level to depressional areas. Profile or internal drainage is adequate in loam and clay soils on sloping topography, but is restricted in the heavier clay profiles, particularly where an impervious solodized B horizon has developed. Very poor profile drainage is associated with the soils on flat to depressional topography.

Most Onion Lake soils range in stoniness from stone-free (S_0) to slightly stony (S_1). Occasional moderately stony areas (S_2) occur, and near Bolney there are local patches of very stony (S_3) soils. The latter condition is not typical of Onion Lake soils but appears to represent a thin, eroded glacial till deposit over the bedrock.

Onion Lake soils have been mapped as heavy clay, clay, clay loam and loam. This wide range in texture is the result of glaciation and subsequent deposition and erosion. Where the soils are developed on parent materials derived from the shale bedrock, heavy clay and clay textures predominate. Loamy textures occur where boulder clay or alluvial and glacio-fluvial deposits overlie the residual shale clay.

Member profiles of the Onion Lake Association belong to the solonetzic group of soils. The heavy clay types exhibit only slight solonetzic development, but the remaining textural types have well developed solonetzic features. Solodized-Solonetz, eroded Solodized-Solonetz ("burn-out" profiles), Solod, Solonetz, and poorly drained Salinized-Solonetz members have been recognized. The Onion Lake Association is the black soil equivalent of the Trossachs and Echo Associations of the Dark Brown and Brown soil zones respectively. Eroded ("burn-out") pits are much less frequent in Onion Lake soil areas, probably because of the more moist climate and better vegetative cover. Generalized descriptions of important Onion Lake member profiles are given below:

Onion Lake Solodized-Solonetz clay profile on steep rolling slopes:

A_1 Horizon.—Black, crushing to dark grey colour. Cloddy to coarse granular structure, with some platy-shaped aggregates. A friable type of soil, with many grass roots present. Clay loam to clay texture (3" to 5" thick).

A_2 Horizon.—Dark greyish-brown, narrow columnar shaped aggregates breaking to thick platy segments (2" to 4" thick).

A_3 Horizon.—Brownish-grey to grey, platy structure (2" thick).

B_1 Horizon.—Whitish coloured at top and very dark brown to black below. Round-topped large columnar structure breaking into hard angular fragmental and nutty aggregates. Heavy clay texture (8" to 12" thick).

B_2 Horizon.—Yellowish-brown, columnar structure, less hard and compact than B_1 (6" to 10" thick).

B_3 Horizon.—Mottled (yellow-brown, light grey, dark grey) massive structure. Moderate lime carbonate content, and indications of soluble (alkali) salts (6" or more thick).

C Horizon.—Mottled dark greyish colours, massive to faintly laminated (shale-like) structure. Heavy clay texture, derived from weathered shale, "alkali" salts present.

Onion Lake Poorly Drained (Salinized) Solodized-Solonetz on nearly flat topography bordering sloughs and marshy areas:

A_1 Horizon.—Very dark grey clay, weak cloddy structure breaking to small platy-granular aggregates.

A_2 Horizon.—Lighter grey in colour, small nutty structure, breaking to plate-like fragments (A_1 to A_2 6" to 8" thick).

B_1 Horizon.—Very dark brown to dark brown, with humus staining. Hard, compact, columnar aggregates, with some round-top development. Heavy clay texture. This horizon becomes yellow-brown in colour at the base, representing a thin B_2 horizon (8" thick).

B_2 Horizon.—Yellowish-brown streaked and spotted with lime carbonate and salts. (8" to 12" or more thick.)

C_1 Horizon.—More greyish in colour, with bluish-grey and rusty spots, poorly drained.

Solonetz Heavy Clay Profile on summit of broad ridge:

A_1 **Horizon.**—Nearly black, granular structured clay.

A_2-B **Horizon.**—Brown, columnar structured, spots of greyish platy material suggest partial leaching.

B_1 **Horizon.**—Dark brown heavy clay, columnar structure, hard and compact, breaking to very hard nutty and fragmental aggregates (8″ to 10″ thick).

B_2 **Horizon.**—Yellow-brown, more friable calcareous clay (6″ to 12″ thick).

C **Horizon.**—Very dark grey to grey-brown; spots of dark shale-like clay, and streaks of lighter grey lime carbonate and probably gypsum. Massive structure, heavy clay texture.

The Solod member of the Onion Lake Association has a combined A horizon of 12″ to 16″ thick, and a relatively thin, very dark coloured B_1 horizon.

Other variations in the thickness and colour of the different horizons are associated with textural variations occurring in Onion Lake soils.

Onion Lake soils are mapped as a complex or mixture with Waseca, Meota and Saline soils respectively. Small local areas of Onion Lake soils may also occur in other soil associations within the Paradise Hill-Lloydminster Upland.

Agriculture.—Most of the Onion Lake soils are classified as poor to fair agricultural types. The best soil appears to be the Solonetz heavy clay member on undulating topography. This soil has a better structure than the dominant Solodized-Solonetz member, and better topography and drainage than the soils of rolling areas and lowland depressions respectively. The best undulating heavy clay is rated at 63, and the Solodized member at 49.

Uneven stands of grain crops were observed on the rolling clay and clay loam soils, and the adverse effect of the eroded depressions was noticeable. The Onion Lake soils found on low, nearly level topography also produce uneven crops, which may be due both to the presence of "burn-out" pits and to the effect of salts and poor drainage in the subsoils.

Poor soil structure, rough topography and the associated high power requirements are handicaps to cultivation in the rolling areas. It is worth noting that the Onion Lake soils are moderately acid in reaction and a few samples have been classified as strongly acid (below pH 5.5). It is possible that such low pH values might make it difficult to secure satisfactory stands of legume crops. Wheat and oats were the only crops observed on these soils during the period of survey work. A further handicap to the utilization of these soils is the difficulty of securing a good supply of water on the upland area north of the Big Gully. This restricts livestock production and the development of cropping systems associated with mixed farming.

WHITESAND ASSOCIATION

Description.—The Whitesand Association consists of black gravelly loams and sandy loams developed on glacio-fluvial deposits. These deposits consist of coarse textured outwash, kames and stream-eroded boulder clay.

In the present area Whitesand soils are of widespread occurrence. The larger areas are located along Shell Brook west of the town of Shellbrook; south of Medstead; at the mouth of Big Gully Creek; on the south side of the North Saskatchewan River between Fort Pitt and Deer Creek; and north and east of Paradise Hill. Smaller areas of these soils occur along the streams and glacial drainage channels of the Turtleford Dissected Plain and the Spiritwood basin, and in the southern end of the Debden Plain. Approximately 200,000 acres of Whitesand soils were mapped in the present surveyed area. Whitesand soils are common throughout the black soil zone south of Township 48, where nearly one million acres were mapped.

The soil landscape of the Whitesand Association is characterized by the coarse sandy to gravelly nature of the surface soil. Small rounded stones (cobble) occur in some Whitesand areas. The vegetative cover may be described as thin parkland type, which has a more arid appearance than is found in medium-textured black soil areas. The grass is relatively thin and the small clumps of trees are thin and somewhat scrubby in appearance. Agriculturally, the Whitesand soils are less well developed than the heavier textured black soils. In most Whitesand areas, uncultivated land is common and some abandoned land may be observed.

Since Whitesand soils are found on various types of glaciofluvial deposits, the topographic conditions show considerable variation. They include nearly level to undulating outwash sandy plains, mixed undulating and rolling areas, stony eroded glacial channels, and rolling to hilly kame deposits. However, for the Province as a whole, undulating topography prevails in Whitesand areas, and in the present survey, over 60 per cent. of the Whitesand soils are mapped as nearly level to undulating. Another 25 per cent. are mapped as mixed undulating and rolling, and about 14 per cent. as rolling to hilly.

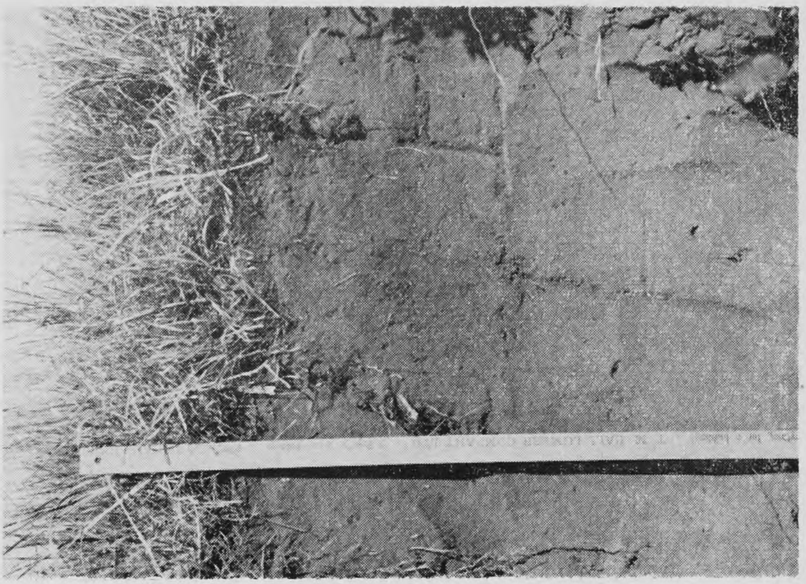
Surface drainage is adequate in most Whitesand areas, except on flat-depressional topography where heavier, more impervious deposits underlie the sandy surface soils. Internal or profile drainage is excessive except in the gritty loam and light loam soils and in general the Whitesand soils are among the most droughty types of the black soil zone.

The Whitesand soils of sandy loam texure are generally stone-free. The gritty and gravelly loams and mixed gravelly loam-sandy loam areas are usually stony and where eroded channels occur are frequently excessively stony (S_4). Although larger stones (boulders) may be common in stony areas, many of the stones are of small cobble size (less than 6″ diameter). Where cobble occurs, the stones are generally very numerous, so that their complete removal is extremely difficult, if not impossible.

Gravelly subsoils and local spots of surface gravel are frequently present in Whitesand areas.

Whitesand soils are mapped chiefly as sandy loam, gravelly loam, and mixed gravelly loam-sandy loam textures. In some areas, for example, along the North Saskatchewan River, south-west of Turtleford, Whitesand light loam has been mapped. Texturally this

PLATE 14



Black soil profile on sandy parent material. Well drained member of Meota Association. Lime carbonate leached to depth of four feet.

Wooded calcareous soil profile—high lime member of Paddockwood Association.

soil represents a gritty loam, that is, a soil with more coarse sand and fine gravel than is usually found in a loam, but which does not contain enough coarse material to make it a sandy loam or gravelly loam. Soils described as gritty loams or light loams may be regarded as being less drought resistant and lower in potential fertility than ordinary loams.

Whitesand soils exhibit various degrees of profile development. The degree of horizon development and the depth of the profile depend upon the texture, topography and the amount of stone and gravel present. Very gravelly and cobbly-stony types, and those occurring on steep slopes have less well developed profiles than the ordinary sandy loams.

Well developed Whitesand profiles consist chiefly of the Hard Columnar member. Shallow Knoll and Poorly Drained members are also common where topographic and drainage conditions favour their development. Occasionally, Calcareous Earth profiles are encountered but these are more common in the black soil areas east of the Missouri Coteau, where the lime content of the glacial drift is higher than to the west.

Generalized descriptions of the more important Whitesand profiles are given below:

Whitesand Sandy Loam on nearly level outwash plain:

A_1 Horizon.—Black, speckled with whitish silica (sand) grains, which gives the surface a "pepper and salt" appearance; friable, soft cloddy structure, breaking easily to single grain (structureless) condition. In deep profiles, a dark brown cloddy-columnar A-B horizon may be present. The total thickness of the A horizon may range from 6″ to 15″.

B_1 Horizon.—Brown to reddish-brown; faint columnar structure, moderately hard and compact. Loamy coarse sand to heavy sandy loam texture (8″ to 12″ thick).

B_2 Horizon.—Yellowish-brown; soft granular structure, and slightly calcareous (limy). This horizon may be well developed or may be merely a thin transitional layer between the B_1 and C horizons.

C Horizon.—Stratified gravelly and coarse to fine sandy deposit, usually slightly to moderately calcareous.

Whitesand Gravelly Loam Hard Columnar Profile:

A_1 Horizon.—Black to very dark brown gravelly loam to gritty light loam; the structure is soft cloddy and breaks readily to a granular and single grain (structureless) condition (4″ to 8″ thick).

B_1 Horizon.—Brown to greyish-brown, large columnar structure, moderately hard and compact. The columns break into small clods and may be crushed to a fine granular and single grain (structureless) condition. The texture of this horizon varies from a heavy sandy loam to a sandy clay loam (6″ to 8″ thick).

B_2 Horizon.—The B_1 horizon may be underlain by a soft, greyish limy B_2 horizon or the B_1 horizon may rest upon a layer of gravel and coarse sand. The B_2 horizon, where present, is light grey or yellow-grey in colour, with a soft granular structure, and a moderately high content of lime carbonate.

C Horizon.—Yellowish-brown to grey-brown, mixed gravelly loam and sand, with very little structure and a low to moderate content of lime.

A gravelly phase of the above Whitesand soils consists of a shallow profile over a layer of gravel and coarse sand. This layer may occur immediately below the A horizon, beneath a thin B_1 horizon, or beneath a thin B_2 horizon. The position of this gravelly layer in

PLATE 15

Soil landscape of Onion Lake Association, showing eroded depressions ("burn-outs").

Soil landscape of Waseca Association, showing dark surface with local grey depression podzolic soils.

relation to the surface horizon largely determines the agricultural value of the soil. The thickness of the gravelly layer is also important since it may range from a few inches to several feet in thickness. In some places what may be called a gravelly-cobbly phase is encountered in the Whitesand soils. In this phase the gravel and coarse sand are mixed with numerous small water-worn glacial stones.

Poorly drained members of the Whitesand Association show considerable variation in texture. These soils often occur on outwash deposits overlying heavier calcareous-saline deposits. Lime carbonate is frequently found in the A_1 horizon, and both lime and "alkali" salts may occur in the B horizon. The B and C horizons are mottled with various colours, and are usually wet and poorly aerated.

The Calcareous Earth member has a very dark grey to nearly black A horizon, and a thin, greyish-brown to dull brown, weakly developed columnar B horizon. Lime carbonate is present in the B_1 horizon and is also frequently present in the A horizon. The B_2 horizon has a light greyish colour and a high content of lime carbonate.

The Hard Columnar member of the Whitesand Association forms the dominant profile of the undulating areas. Flat-depressional topography is associated with poorly drained Whitesand soils. Calcareous Earth and Shallow Knoll profiles are encountered in rolling areas, along with locally occurring Columnar and Poorly Drained types.

In the present area Whitesand soils have been mapped as complexes or mixed soil areas with Waseca, Oxbow, Whitewood, Glenbush and Meadow soils. The Whitesand soils are distinguished by their coarse sandy-gravelly textures. The Glenbush Association is formed on deposits similar to those of the Whitesand, but Glenbush soils have a leached, greyish A_2 horizon.

Agriculture.—The Whitesand soils are among the poorest agricultural soils of the black soil zone. They are low in drought resistance and after some years of cropping their potential fertility decreases more rapidly than that of heavier textured black soils. Frequent gravelly, cobbly and stony areas are additional detrimental features. The Whitesand soils, however, are definitely superior to the Biggar and Chaplin soils, which represent the coarse textured associations of the Dark Brown and Brown soil zones respectively.

The nearly level to undulating gritty and gravelly loams which are not excessively gravelly or stony are the most desirable Whitesand soils. These types are rated at 47. Wheat, rye and some sweet clover are grown, and hay and livestock production are important enterprises. The sandy loam soils of good topography are also largely cultivated. These soils are, however, less drought resistant and more subject to wind erosion than the loamy types. Unless handled with care, they are of little value. The Whitesand sandy loam is rated at 31.

The very stony or gravelly soils and those on rough topography represent very poor to non-arable types. Some of these soils have never been cultivated and others have been abandoned. In some places further abandonment of cultivated land would be desirable. Seeding down these poorer soils to grasses and legumes would improve their value as pasture or hay lands. The maintenance of organic

PLATE 16

Soil landscape of moderately rolling Whitesand sandy loam. Such slopes (13%) approach the limit of practical cultivation.

Soil landscape of Glenbush sandy loam on strongly rolling topography (20% slopes). Such slopes are too steep to cultivate.

matter and the control of erosion should be the first consideration in their management. Straight grain cropping over a long period of time will not achieve these desirable conditions.

Wind erosion is frequently a serious problem on Whitesand sandy loams. Although the effects of drifting are not so noticeable as on finer textured sandy soils, the Whitesand soils may suffer a serious loss of organic matter, clay, silt and nutrient elements. Some damage may also occur from water erosion in rolling areas.

MEOTA ASSOCIATION

Description.—The Meota Association consists of black fine textured sandy loam soils developed on sandy glacial alluvial-lacustrine deposits. In some places these deposits have been re-worked by wind. In the present area Meota soils occupy a relatively small acreage, only 56,000 acres having been mapped. The larger and more important areas of these soils occur in the main belt of black soils covered in previous surveys, where over 800,000 acres of Meota soils were mapped.

The Meota soils of the present surveyed area occur chiefly north of Prince Albert; near Shellbrook; on the southern edge of the Turtleford Plain around Edam; and on the Lloydminster Upland south of Paradise Hill and in the areas around Rex and Greenstreet.

The soil landscape of the Meota Association is characterized by the sandy nature of the surface, the general absence of stones and the open parkland type of native vegetation. Evidence of present or former wind erosion is also a typical feature. The Meota soils on the Lloydminster Upland are influenced by the rolling to hilly nature of the country, and hence occur on steeper slopes than is typical of most Meota soils.

In the present survey about 20,000 acres of Meota soils are mapped as nearly level to undulating, about 27,000 acres as rolling, and 3,000 acres as hilly.

The surface drainage of Meota soil areas is satisfactory, except in local flat-depressional areas. Internal or profile drainage varies from somewhat poor in shallow Meota light loam profiles overlying clay, to satisfactory in undulating light loam and very fine sandy loam profiles, and to excessive in deep fine sandy loam profiles. The fine sandy loams, particularly on upper slopes, are the least drought resistant of the Meota profiles.

Stones are rarely an important factor in the utilization of Meota soils. Most of them are stone-free and the remainder are usually not more than slightly stony (S_1). Where stones are more numerous it will generally be found that Meota soils are intermixed with soils developed on glacial till deposits. Local spots of gravelly subsoils are occasionally encountered notably in Meota fine sandy loam areas.

Most of the Meota soils are mapped as fine sandy loam, very fine sandy loam and sandy light loam. The term "sandy light loam" is discussed under the Shellbrook Association. North of Lloydminster shallow Meota soils over clay have been mapped. The underlying clay appears to have weathered from the Cretaceous bedrock, with

the Meota soil representing a surface deposit of glacial or post-glacial age. Where the clay is within three or four feet of the surface, it is an important aid to the storage of soil moisture, and such areas are indicated on the map as Meota sandy types underlain by clay.

The Meota Association consists chiefly of Hard Columnar and Shallow or Thin Columnar profiles. Some Solonetzic profiles occur in the soils associated with clay subsoils, and Poorly Drained members occur on flat lowlands. Shallow Knoll profiles occur on the tops of ridges in rolling areas.

Generalized descriptions of the Meota profiles are given below:

Meota Hard Columnar fine sandy loam profile:

A_1 **Horizon.**—Very dark grey-black ("pepper and salt" effect); soft cloddy structure, easily crushed to granular and single grain (structureless) condition (6" to 12" thick). In well drained upland positions an A_2 horizon may be present. This horizon is a dark greyish-brown light loam or heavy fine sandy loam, with a faint columnar structure, and ranges from 2" to 6" thick.

B_1 **Horizon.**—Bright brown to dark greyish-brown; large blocky-columnar structure, moderately compact, and breaking to granular condition. Light loam to sandy clay loam texture (6" to 10" thick).

B_2 **Horizon.**—Yellow-brown; weak columnar structure; less compact than B_1 and may contain lime carbonate. This horizon is not always well developed and may occur only as a thin transition layer at the base of the B_1.

B_3 **Horizon.**—Light brownish-grey to yellow-grey very fine sand. Loose (structureless) to weakly laminated structure. This horizon has a slight to moderately high content of lime carbonate.

C **Horizon.**—Yellow-grey to yellow-brown; loose structureless loamy fine sand, with slight to moderate content of lime carbonate.

The very fine sandy loam and sandy light loam profiles are slightly heavier textured and tend to be somewhat shallower. Lime carbonate is present as indicated above in most Meota soil profiles. However, the Meota soils occurring on the Lloydminster-Paradise Hill Upland are associated with relatively low lime deposits and hence the profiles may be lime-free or contain slight amounts of lime in the parent material.

Shallow Meota sandy light loam over clay:

A_1 **Horizon.**—Black; cloddy structure, moderately hard and crushing to fine granular aggregates (6" to 8" thick).

B_1 **Horizon.**—Reddish-brown, hard columnar (6" to 8" thick).

B_2 **Horizon.**—Yellowish-brown, massive to faint columnar structure (8" to 12" thick).

D_1 **Horizon.**—Dark greyish heavy clay; hard, compact (solonetzic) structure (4" to 6" thick).

D_2 **Horizon.**—Dark grey heavy shale-like clay.

In other places a deeper Meota profile occurs, in which there may be a C_1 or parent material horizon above the clay. The clay in such soils will occur at three feet or more below the surface. It is probable that the Meota soils underlain by clay and those occurring on lime-free sandy deposits should eventually be classified in a new association. The Solonetzic Meota profile has a granular-cloddy A_1 horizon, the cloddy structure being more common in the heavier textured soils. A thin, dark grey, platy A_2 horizon is often present. The B_1 horizon is very dark brown to dark greyish-brown, with a hard columnar

structure, breaking into hard cubic aggregates. Salts may be present in the lower B and C horizons, or the lower B may be underlain by heavy bedrock clay or by boulder clay of the Waseca type.

Shallow Knoll members, particularly in the fine sandy loams, are characterized by thin, poorly developed profiles, in which the usual horizon sequence may not be clearly defined. Under cultivation this soil is marked by a light coloured, loose sandy surface, since the soils on knolls and ridges are usually the first to be affected by wind erosion. The A horizon of the Poorly Drained member of the Meota Association has a greyer colour than that of the well drained Columnar member. The B_1 horizon is dark greyish-brown to dark grey, mottled with yellow, grey and rusty colourings, and usually has a weakly developed cloddy-columnar structure. Mottled colours and massive structures occur in the lower B and C horizons. Varying amounts of soluble salts and lime carbonate may occur throughout the profile.

Meota soils are mapped as complexes with Onion Lake, Waseca, Lloydminster and Shellbrook soils. The Meota soils are easily distinguished from the first three associations by the lighter textures and absence of stones. Meota surface soils are darker coloured than Shellbrook soils, which represent Meota types which have undergone some podzolic degradation or leaching under the influence of a woodland vegetative cover. Near Edam, Meota soils are also mapped as a complex with Undifferentiated Sands. The latter are lighter coloured, incoherent (or loose) sand deposits, with little or no profile development.

Agriculture.—Compared to medium and heavier textured black soils, the Meota soils are less drought resistant and more liable to drift. They are, however, superior in drought resistance to the Whitesand sandy loams, and mixed gravelly-sandy loams. The very fine sandy loams and sandy light loams of nearly level to undulating topography are the best agricultural types of Meota soils. The soils underlain by clay are definitely superior to the ordinary Meota soils, particularly where the clay is within 12 to 36 inches of the surface. It is assumed that the clay subsoil prevents the loss of moisture by percolation, and this makes the overlying Meota profile much more drought resistant than the deep sandy profiles. Meota light loams and very fine sandy loams are classified as fair agricultural soils (ratings of 53 and 51) and the Meota soils over clay as moderately good (ratings up to 63). The fine sandy loam is less productive and is rated at 43.

The maintenance of productivity and the control of wind erosion are vital to the successful utilization of Meota soils. Under continuous cultivation and cropping, losses in soil fertility and deterioration of soil structure become progressively greater. It is true that because of the more favourable soil moisture conditions there is less difficulty in meeting these problems on Meota soils than on the corresponding Asquith and Hatton soils of the Dark Brown and Brown soil zones. In too many Meota soil areas, however, straight grain growing is still the prevailing system of farming. The recurrence of active wind erosion as observed in 1946-48 is sufficient indication that Meota soils require a system of management that will control erosion. It is

important to remember that severe wind erosion not only reduces the crop yield of the current season, but may reduce the soil's productive capacity for future years. Both humus and clay are removed from the surface horizon, and sandy textured soils are relatively low in these valuable constituents to begin with. Furthermore, the drifted material is lighter in texture than the original soil, so that in very severely eroded sandy loams the drift deposit may be only loamy sand or sand. Such material is a menace to the adjacent productive soils since the sandy drift induces erosion of the better soils or in some places buries them.

Mixed farming practices, including the use of grasses and legumes and the keeping of livestock are being followed on some Meota soils. Such practices fit into a system of erosion control and also assist in maintaining soil fertility. In particular, the use of livestock provides a source of the best fertilizer for sandy soils—barnyard manure.

BLAINE LAKE ASSOCIATION

Description.—The Blaine Lake Association consists of medium to heavy textured soils on silty glacial lacustrine deposits. In most places the lacustrine deposits are relatively thin and are underlain by boulder clay. In the present area the Blaine Lake soils are inextensive, occurring mainly in the east end of the Lloydminster Upland on either side of the Big Gully; around Turtleford; and east of Prince Albert on either side of the North Saskatchewan River. A few small areas occur in the general Shellbrook district. Only 50,000 acres were mapped in the present survey, whereas over one million acres of Blaine Lake soils were mapped in the main Black Soil Zone covered in previous surveys.

The soil landscape of the Blaine Lake Association is characterized by the dull greyish tinge of the cultivated soil—which is not so dark as most of the other black soils. There are few to no stones on typical Blaine Lake soil areas. Saline (alkali) sloughs and lakes are a common feature, although these are not so numerous in the present area as in the main belts of Blaine Lake soils. The vegetative cover is a parkland mixture of grassland and clumps or "bluffs" of aspen and willow. In general, Blaine Lake areas are well developed agriculturally.

About one-half of the Blaine Lake soils were mapped on nearly level to undulating topography, and the remainder on mixed undulating-rolling and gently to moderately rolling topography. Surface drainage of the Blaine Lake soil areas is quite adequate on undulating slopes, but somewhat excessive on steeper slopes of rolling topography. Poorly drained to undrained areas are associated with the lower lands and depressions. Internal or profile drainage is satisfactory in the columnar-structured profiles and moderately good in solonetzic profiles and heavy textured soils. Poor to very poor internal drainage is associated with the soils of flat-depressional areas.

Stones are rarely a serious factor in Blaine Lake soil areas, usually ranging from none to occasional (S_0 to S_1). Moderately stony (S_2) conditions occur where Blaine Lake soils are intermixed with soils developed on boulder clay, and on the outer margin of Blaine Lake areas where the underlying boulder clay is close to the surface.

Most of the Blaine Lake soils of the present area consist of loams, with some clay loam and silty clay loam, and a very small amount of clay. The profiles of the Blaine Lake Association consist chiefly of Solonetzic and Hard Columnar members. Calcareous Earth, Shallow Knoll and Poorly Drained profiles are important local members. In places where a well established tree cover exists, slight podzolic leaching has occurred and the profiles may belong to the complex Degraded Black-Solonetzic types.

Generalized descriptions of Blaine Lake member profiles are given below:

Blaine Lake Solonetz Profile:

A_1 Horizon.—Very dark grey to nearly black; friable small cloddy structure, breaking easily to graular condition (3″ to 4″ thick).

A_2 Horizon.—Dark grey to dull brownish-grey; cloddy-platy structure (4″ to 6″ thick).

B_1 Horizon.—Reddish-brown to medium brown; large blocky structure, but separating into medium sized, hard, compact columns which in turn break into hard cloddy and angular fragmental aggregates.

B_2 Horizon.—Yellow-brown; columnar structure, less compact and tough than B_1. The B_2 horizon usually occurs as a gradual transition in colour and structure to the lower B horizon. The total thickness of the B_1 and B_2 horizons ranges from 8″ to 14″.

B(ca) Horizon.—Yellowish-grey to brownish-grey; massive structure, but soft and friable and crushing easily to fine granular condition; high content of lime carbonate (12″ or more thick). Frequently this horizon grades into the upper parent material so that it is difficult to separate the B(ca) from the upper C horizon.

C Horizon.—Faint yellowish-grey to medium grey, streaked with soluble salts and gypsum; laminated structure, breaking easily to granular form. The content of lime carbonate is fairly high, but usually less than that of B(ca). Tiny water-worn glacial pebbles are often present in this horizon and may also occur in the B horizon. In some places the lacustrine deposit is thin and at depths of 3 to 5 feet the C horizon may be underlain by a D horizon composed of resorted boulder clay.

The above profile represents the most common solonetzic soil in the Blaine Lake Association. More advanced stages of this type of soil formation also occur. These include the Solodized-Solonetz profile, characterized by the round-topped columnar structured B_1 horizon, and the Solod profile.

The Solod has a dark cloddy-granular A_1 horizon about four inches thick. The A_2 horizon has a dull brown to grey-brown colour and a columnar structure which breaks into flat-topped, thick plate-like segments (6″ to 8″ thick). There may be a thin greyish coloured, platy A_3 horizon. The columnar B_1 horizon may have a dark shiny coating, probably due to the deposition of organic material leached from the A horizons.

Hard Columnar member: A_1—very dark brown to black; granular to cloddy structure (4″ to 8″ thick). A_2 or transition A-B horizon —dull brown to dark brown; faint columnar structure, separating into small clods (4″ to 6″ thick). B_1 horizon—greyish-brown to medium brown; large blocky-columnar structure, moderately compact to very compact, and breaking to coarse granular aggregates. Yellow-brown colours may occur toward the bottom of the columns, and a B_2 horizon may be separated in the deeper profiles. The total depth of the

columnar B horizon varies from 6 to 14 inches. The lower horizons are similar to those described under the solonetzic member.

High Lime member: A horizon—very dark grey; granular to soft cloddy structure; slightly calcareous to lime-free (4" to 8" thick). B_1 horizon—grey-brown to yellow-brown; irregular columnar structure, slight to moderate content of lime (4" to 6" thick). B_2 horizon—light grey to yellowish-grey; soft massive structure; very high content of lime carbonate. This horizon grades into the parent material or C horizon.

The complex degraded black-solonetzic profile has a dark grey, platy A_1 horizon and a grey, platy A_2 horizon, overlying B horizons similar to those described for the solonetzic members of the Blaine Lake Association. This complex profile is most commonly found on higher well drained positions with a wooded vegetative cover. The B_2 horizon often grades into a pebbly resorted boulder clay which may mark the transition between the shallow lacustrine deposit on the surface and the underlying boulder clay.

Shallow Knoll and Poorly Drained members of the Blaine Lake Association may be identified by their respective topographic positions and by the key profile features listed in Table 7, page 48. The poorly drained Blaine Lake profiles, as is common in all Associations where solonetzic soils predominate, include salinized and weakly developed solonetz types.

The ordinary solonetz and the hard columnar members are the dominant profiles of medium textured soils on undulating areas. The solonetz profile occupies slightly lower and flatter positions within the well drained upland. Associated with this profile are local areas of solodized-solonetz and solodi soils. The solodized-solonetz profile occupies still lower and more poorly drained positions, and frequently lies adjacent to depressions consisting of poorly drained Blaine Lake and Saline soils. The highest positions in smooth undulating areas are often occupied by the high lime member.

Heavier textured, undulating areas of Blaine Lake soils consist chiefly of a complex of Solonetzic and Hard Columnar members, and local areas of Saline soils.

In rolling areas high lime and shallow knoll profiles occupy the upper slopes, while hard columnar profiles predominate on intermediate slopes. Lower slopes consist of solonetzic and poorly drained members, with Saline (Alkali) and Meadow soils in the lowest depressions.

Where complex podzolic profiles occur they are associated with woodland vegetation and well drained upland topography. Local groves of trees surrounding slight depressions within the upland are associated with depression podzol profiles.

The Blaine Lake Association represents a wide variety of soil profiles, textures, and topographic conditions. More detailed studies may result in the separation of one or more new soil associations out of the present complex. Broadly speaking, the Blaine Lake soils are characterized by varying degrees of solonetzic development, and occur on shallow glacial lake deposits situated within the Black Soil

Zone. The high lime profiles may ultimately form another association, but at present they may be accounted for largely by their topographic position. The parent materials of the Blaine Lake soils are sufficiently uniform to justify the present classification, with the exception of the clay areas. The latter may also represent a different soil association. Another important factor is the position of the Blaine Lake soils in relation to the Black Soil Zone. Some of these soils occupy the more moist sections and possess deep black profiles. Examples of this type occur in the Domremy, Cudworth, and Rosthern districts. Shallow black Blaine Lake soils occur in the more westerly section of the Black Soil Zone. These differences are partly indicated by the range in horizon depths given in the foregoing descriptions.

Blaine Lake soils are, in places, mapped as mixed areas with Waseca, Whitewood and Shellbrook soils respectively. In such areas the Blaine Lake soils are usually found on smooth, well drained, lower positions.

Agriculture.—The Blaine Lake Association contains some of the best agricultural soils in the Province. The undulating silty clay loam and clay types are the most valuable. These soils are highly fertile and drought resistant. The absence of stones and the smooth topography favour large scale grain farming, and modern power equipment is used to a considerable extent. The clay is rated at 79 and the silty clay loam at 70.

The undulating silt loam and loam soils are also good agricultural types, although they do not equal the heavier types in drought resistance (ratings 60 and 59). The rolling phases of the Blaine Lake soil are somewhat less valuable, due to the loss of moisture by run-off, the greater percentage of waste land and the higher costs of tillage operations. Areas of poorly drained and strongly developed solonetzic soils are also of lower agricultural value than the better Blaine Lake soils.

The Blaine Lake soils are used mainly for grain production, and wheat is the most important crop. Coarse grains are also grown to a considerable extent. Forage crops can be produced successfully but are not grown on a large scale. The growing of forage crops is usually associated with livestock production, and on many Blaine Lake soils it is difficult to secure a satisfactory supply of water for stock.

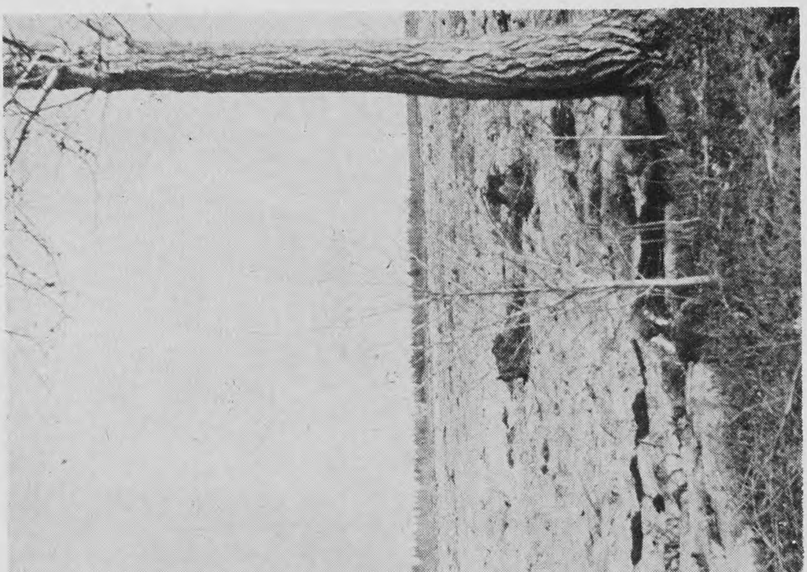
The main problems associated with Blaine Lake soils are wind and water erosion, weeds, lower productivity of poorly drained solonetzic and depression podzol soils, and in some areas, frost hazard. Wind erosion is a serious problem in dry seasons, particularly on the silty clay loam and clay types. Water erosion is most serious on rolling lands.

CANORA ASSOCIATION

Description.—The Canora Association consists of thick black, highly calcareous, medium textured soils on silty glacial lacustrine deposits. In the present area these soils occupy a very small acreage (less than 3,000 acres), and hence are relatively unimportant in comparison with the more extensive soil associations. The main belt of

PLATE 17

Soil landscape of Waseca loam on rolling topography. The narrow steep-sided ridges are characteristic. Tree growth on northern slope.



Soil landscape of Kamsack clay loam on nearly level topography. Such land is all arable and little soil moisture is lost by run-off.

Canora soils is located in the eastern section of the black soil zone south of Township 48, where nearly 500,000 acres were mapped. The Canora soils of the present survey are confined to the district around Claytonville, about 15 miles east of Prince Albert and north of the Saskatchewan River.

For a full description of the Canora Association, the reader is referred to Soil Survey Report No. 12. The small acreage of the present survey can be covered in the following brief statement:

The Canora Association occurs on nearly level to gently undulating topography. There are no stones. Surface drainage is adequate in most places, being somewhat slow on the lowest land. Internal or profile drainage is satisfactory except in the profiles on the flatter, lower land, where it is somewhat restricted in the subsoil. Most of the soils were mapped in loam and clay loam textures, with a small area of silty clay loam.

The dominant profile of the Canora Association in the present surveyed area is the Calcareous Earth member. Moderately Poorly Drained members occupy local areas of slightly lower land. Generalized descriptions of Canora soils are given below:

Canora Calcareous Earth Profile:

A Horizon.—Black, when crushed showing a very dark grey tinge; soft cloddy structure with faint platy appearance, and crushing easily to friable granular aggregates. A very dark grey, faintly columnar lower section of the A horizon is usually present. This may contain a slight amount of lime carbonate. Where this sub-horizon is distinguished, it may be regarded as an A_2 or transitional A-B. (Thickness of total A horizon 10″ to 14″.)

B_1 Horizon.—Very dark grey-brown; columnar structure, breaking easily to soft cloddy and granular aggregates. Slight to moderate content of lime carbonate (8″ to 10″ thick).

B(ca) Horizon.—Faint yellow-grey, massive to faintly laminated structure, soft and friable. High content of lime carbonate. This horizon may be one foot or more in thickness, but it is difficult to separate it from the C_1 horizon particularly when the soil is moist and these horizons assume a yellow-brown (buff) colour.

C_1 Horizon.—Yellow-grey; silty to very fine sandy lacustrine deposit. Faintly laminated to occasional thick banded deposit. High content of lime carbonate.

The Poorly Drained member most common in the present area represents a moderate degree of restricted drainage, rather than the wetter, salinized type occurring in the main areas of Canora soils. The A horizon is very dark grey in colour; soft cloddy to faintly columnar structured, with a tendency to break into weakly developed platy aggregates. Lime carbonate is present to the surface (12″ to 16″ thick). The B_1 or transitional A-B horizon is greyish-brown with rusty spots; faint thick platy structure (4″ to 8″ thick). The lower B and C horizons are mottled with yellow, light grey, dark grey and rusty streaks, and are usually very moist.

The Canora soils are in part mapped as a complex with Kamsack soils. The latter represent former grassland profiles which have been modified as a result of a later invasion of trees, so that they now show slight podzolic leaching. The Canora soils bear considerable resemblance to the Weirdale soils both in general profile features and

in type of parent material deposit. The Weirdale soils, however, are associated with a forest cover and are definitely lower in organic matter and nitrogen.

Agriculture.—The Canora soils have thicker than average A horizons and are highly productive types. The smooth topography, lack of stones and the open parkland vegetation have favoured their agricultural development. They are classified as good to excellent soils (ratings 63 to 77). In the present area evidence of slight wind erosion was observed, but no severe wind and water erosion has occurred such as was observed in the main areas of Canora soils.

MEADOW LAKE ASSOCIATION

Description.—The Meadow Lake Association consists of thick black solonetzic soils on silty clay glacial lacustrine deposits. These soils occur mainly on the Beaver River Plain in the vicinity of the town of Meadow Lake. Small areas also occur west of Makwa (Loon) Lake and at Flat Valley and Goodsoil. Approximately 58,000 acres were mapped. While this represents a small area, the Meadow Lake soils are more important than their acreage would imply. They form a distinct soil association, so that no other soils so far mapped in the Province are quite similar to them. Furthermore, the reputation of the Meadow Lake area as a good agricultural district is due largely to the productivity of these soils. In fact, they, along with the Beaver River Association, represent a local island of good soils within a poorer surrounding area.

The soil landscape of the Meadow Lake Association is characterized by the very dark colour of the surface soil, flat-depressional to gently undulating topography, absence of stones and the luxuriant stand of grasses and shrubs interspersed with well developed stands of aspen, black poplar and willow. The cultivated land is well developed and heavy stands of grain and forage crops are also characteristic.

All of the Meadow Lake soils are found on nearly level to gently undulating topography. Somewhat rougher topography is associated with mixed areas of Meadow Lake and Makwa soils, and with Meadow Lake soils bordering creek channels. Flat-depressional topography occurs where Meadow Lake soils are intermixed with the Meadow-Bog soil complex.

Surface drainage of Meadow Lake soil areas varies from good to poor and very poor. The undulating land is generally well drained, but flat-depressional areas associated with Meadow and Bog (peat) soils are very poorly drained and frequently liable to flooding. Thus, in wet seasons, or when run-off water is high, both hay land and cultivated land may flood and become temporarily water-logged. Internal or soil profile drainage is adequate in most Meadow Lake soils of undulating topography. Various degrees of restricted soil drainage are associated with the well developed solonetzic soils, such as the solodized-solonetz, particularly in the heavier textured types. Wet, very poorly drained profiles occur on flat topography adjacent to Meadow Bog depressions.

Meadow Lake soils are typically stone-free. Occasional boulder clay knolls occur just north of the town of Meadow Lake, and along the western edge of the Meadow Lake soil belt where the lacustrine deposit is thin.

Clay loam and loam are the dominant textural classes. The soil textures are smooth and silty-like but as a rule the soils do not contain enough silt to qualify as silty textural types. Several small areas of clay have also been mapped.

The Meadow Lake Association consists principally of thick black solonetzic profiles. These include Solonetz-like, Solonetz, Solodized-Solonetz and Solod members. Poorly Drained members are also common, notably in flat-depressional areas. There is also evidence of the beginning of podzolic soil formation in the profiles occurring on well drained sites under wooded vegetative cover. It is frequently difficult to decide the relative importance of the process of podzolization and that of solonetzic weathering. In general, the podzolic development has not proceeded to the point where Meadow Lake profiles can be regarded as degraded black soils. The leached A_2 and A_3 horizons occur well below the surface and are considered to be associated with the solonetzic process acting upon black grassland and former meadow soils. The A_1 horizons, even under a tree cover, are still relatively thick, dark in colour and high in organic matter and nitrogen. The chief evidence of podzolic weathering is seen in the development of a surface layer of partially decomposed plant material (A_0 horizon). The development of a lighter coloured more platy A_1 horizon, associated with a greater degree of podzolic leaching, may also be observed in wooded areas. However, such features are also associated with solodization, or leaching, of solonetzic soils. Profiles with thinner and lighter coloured A_1 horizons were classified as degraded black and complex degraded black-solonetzic soils and placed in the Beaver River Association.

Generalized descriptions of Meadow Lake member profiles are given below:

Meadow Lake Solonetz-like Profile:

A_1 Horizon.—Black to very dark grey; granular to faint platy-granular structure; high content of organic matter (12″ to 14″ thick).

A_2 Horizon.—Medium grey with faint yellow tinge; platy structure, crushing to granular aggregates. (3″ to 4″ thick).

B_1 Horizon.—Brown to dark greyish-brown; columnar structure, sometimes only moderately developed, breaking to coarse granular aggregates (6″ to 10″ thick).

B_2 Horizon.—Yellowish-brown; soft massive to faintly columnar, slightly calcareous (2″ to 6″ thick).

C_1 Horizon.—Medium grey to yellowish-grey; faintly laminated, moderate to fairly high lime carbonate content (6″ or more thick). Sometimes this horizon may be regarded as a B horizon of lime accumulation, B(ca).

C_2 Horizon.—Banded (varved) light grey and dark grey-brown calcareous silty clay, some mottling from whitish streaks of lime and sometimes of salts, and from yellow and darker grey streaks and spots.

Meadow Lake Solonetz Profile:

A_1 Horizon—Black humus surface and dark grey below, with spots of medium grey colour; platy structure, crushing to fine and medium granular aggregates (8″ to 10″ thick).

A_2 **Horizon.**—Grey; faint columnar or cloddy structure present, but when handled breaking to platy structure and crushing to granular aggregates (3" to 5" thick).

B_1 **Horizon.**—Dark brownish-grey; large columnar structure, hard and compact, breaking to hard nutty and coarse granular aggregates (10" to 12" thick).

B_2 **Horizon.**—Grey-brown to faint yellow-brown; columnar structure, less hard and compact than B_1, slightly calcareous.

Meadow Lake Solodized-Solonetz Profile:

A_1 **Horizon.**—Black; high in organic matter and grass roots, granular structure (2" to 3" thick).

A_2 **Horizon.**—Dark brown; platy structure (3" to 5" thick).

A_3 **Horizon.**—Grey; thick platy structure separating into thinner segments in which the under-side is darker than the upper (2" to 3" thick).

B_1 **Horizon.**—Dark grey heavy clay; columnar, slightly round-topped structured, very hard and compact, breaking to nutty and angular-fragmental aggregates (8" to 12" thick).

B_2 **Horizon.**—Mottled lighter grey; massive structure; calcareous.

Meadow Lake Solod Profile:

A_0 **Horizon.**—Black; loose granular peaty loam, (may be absent) (0" to 2" thick).

A_1 **Horizon.**—Very dark grey; soft granular structure; loamy texture (4" to 5" thick).

A_2 **Horizon.**—Dark grey; columnar-thick platy structure; heavy loam texture (4" to 5" thick).

A_3 **Horizon.**—Light greyish-brown; platy structure, crushing to granular; heavy loamy texture (3" to 4" thick).

A-B Horizon.—Brownish-grey; thick platy structure breaking to hard small nutty aggregates; apparently represents degradation of upper section of former B horizon. Heavier texture than above (2" to 4" thick).

B_1 **Horizon.**—Mixed dark grey and dark brown; columnar structured; heavy clay textures (4" to 8" thick).

B_2 **Horizon.**—Slightly calcareous as described for other profiles.

Meadow Lake Poorly Drained Profile:

A_0 **Horizon.**—Brown peat, raw and partially decomposed (2" to 4" thick).

A_1 **Horizon.**—Very dark brown to greyish-brown; shotty structure; heavy texture (8" to 12" or more thick).

B_1 **Horizon.**—Greyish-brown, mottled with rusty, dark grey, bluish-grey, etc.; faint columnar structure, compact and heavy textured (12" or more thick).

Lower B and C Horizons.—Mottled colours, wet and very poorly drained (gley-like).

Meadow Lake soils have been mapped as complexes with Beaver River, Makwa, and Meadow-Bog soils. The Meadow Lake soils are darker in surface colour than the Beaver River, and somewhat darker than the Makwa soils. The latter are also distinguished by being developed on modified (resorted) boulder clay.

Agriculture.—The Meadow Lake Association includes some of the most fertile and productive soils in the Province. They are particularly high in potential fertility or total content of important plant nutrients, as indicated by the thick A_1 horizons with their high organic matter, nitrogen and phosphorous contents. The agricultural development of these soils was also favoured by the smooth topography, absence of stones and the presence of open grassland between the wooded areas.

The Meadow Lake soils have been classified as good to excellent agricultural types, with ratings of 62 to 77. On potential fertility alone many of the soils would rate higher, but the location of the soils in an area with a short growing season and a distinct frost hazard are adverse factors. This is particularly true in wet seasons, when the vegetative growth is tall and heavy, and lodging and delayed ripening are common. In addition, the heavier textured and flat-depressional areas are liable to temporary flooding or water-logging in wet periods. It is considered, however, that the adverse climatic conditions are most evident where straight grain growing is practiced. The greater use of legumes and grasses as forage crops would probably fit in better with the Meadow Lake soil and climatic conditions. It is probable that the regular use of phosphate fertilizers would assist in bringing about stronger stands and earlier maturity of crops, particularly of grains.

Wheat, oats, and barley are the most extensively grown crops, but some alfalfa and grasses are also produced. Evidence of slight wind and water erosion has been observed in places, but erosion is not serious. The improvement of drainage and the control of seasonal flooding are more important problems of Meadow Lake soil areas.

The Transition (Degraded Black and Wooded Calcareous) Soils

The Degraded Black soils of the present surveyed area are represented by the following Associations:

Whitewood	Kelsey	Nipawin
Horsehead	Glenbush	Kamsack
Makwa	Shellbrook	Tisdale
Pelly	Whitefox	Beaver River

Wooded Calcareous Associations are: Paddockwood, Weirdale, and Carrot River.

The Horsehead, Makwa, Kelsey, Glenbush, Whitefox, Nipawin and Beaver River soils represent new Degraded Black Associations, not hitherto shown on Saskatchewan soil maps. The three Wooded Calcareous Associations are also newly established.

The term "Transition" is used to cover the above soils because they form types transitional in character between the black grassland soils and the grey podzolic wooded soils. In addition, the term is also used because there is no major belt or zone composed of the Degraded Black and Wooded Calcareous soils, but rather a belt in which these soils are interspersed with Black and Grey Podzolic types.

The Degraded Black Associations occur chiefly between the Parkland Prairie and the Boreal Forest Region. Islands of Degraded Black soils also occur within the forest region, as on the Beaver River Plain and on the Coteau. The Degraded Black soils occur under a forest cover which is considered to be of more recent origin than that of the true forest region. Many of these soils are regarded as former black grassland profiles which have been changed by the influence of a later invasion of trees. The major profile of these soils

PLATE 18

Soil landscape of mixed Whitewood and Waitville soils on undulating topography.

Soil landscape of Waitville loam on nearly level topography.

—the relatively dark, humus-bearing A_1 horizon and the lighter coloured, more leached A_2 horizon—suggest the above sequence. Furthermore, all gradations between a black soil and a grey podzolic soil may be observed in degraded black profiles.

The Wooded Calcareous soils, on the other hand, afford no present indication of a former state of black soil development. Some of them may have existed as Meadow soils for a short time, but in general they are definitely lower in organic matter than comparable black soils; on the other hand, they are only slightly leached as compared with the Degraded Black soils. The Wooded Calcareous soils are formed on calcareous (limy) deposits under a wooded to peat vegetation. It would appear that the presence of considerable lime, the incomplete drainage and possibly the relatively recent age of these soils have combined to prevent the full development of a leached grey (podzolic) profile.

The Wooded Calcareous soils are located chiefly east of the Missouri Coteau on the Debden and Shellbrook Plains and the eastern section of the Saskatchewan Lowland. Smaller areas of these soils occur in the Spiritwood basin and near Midnight Lake.

Black-grey soil profiles are illustrated in Fig. 6.

WHITEWOOD ASSOCIATION

Description.—The Whitewood Association consists of degraded black loamy soils developed on undifferentiated boulder clay. The term "undifferentiated boulder clay" is defined under the Oxbow Association. The Whitewood soils may be regarded as former Oxbow soils which, under the influence of an invasion of wooded or forest vegetation, have become partially leached or podzolized, so that they are intermediate in character between the true black and grey podzolic soil types.

The Whitewood soils are the most extensive of the degraded black soils, and occupy 570,000 acres of the present surveyed area. The larger areas of these soils occur on the Prince Albert Park Upland; on the Bodmin Plain; throughout the southern section of the Coteau and its western extension; and throughout the Turtleford Plain. The Whitewood soils are also the most extensive degraded black soils in the region covered by Soil Survey Report No. 12, where they occupy over one million acres.

The soil landscape of the Whitewood Association is characterized by a succession of knoll or ridge, intermediate slope and depressional topography—the "wavy" relief associated with soils formed on morainic deposits. Glacial stones and boulders are also a feature of Whitewood areas. The natural vegetation is a wooded cover of aspen, black poplar and willow. The surface colour of cultivated soils is a dark grey to brownish-grey, and this is a useful feature in recognizing these soils when they occur as a complex or mixture with black types. The agricultural development on Whitewood soils varies with the degree of leaching, topography and density of tree cover. In general, Whitewood soils are not as well developed agriculturally as comparable types of black soils.

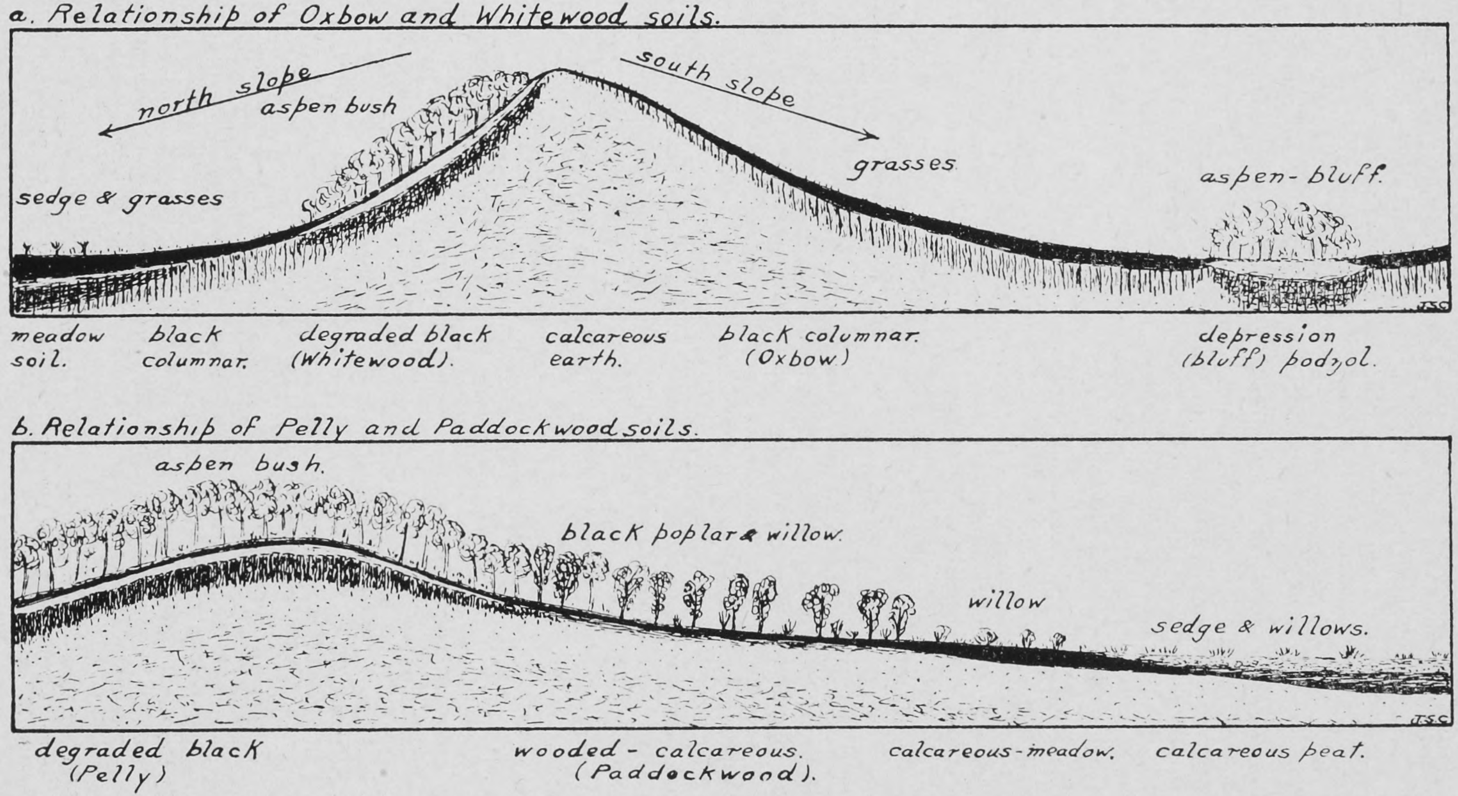


FIGURE 6
Profile Relationships in the Black-Grey Transition Belt.

The Whitewood soils occur on gently undulating to hilly topography. Almost one-half of the total acreage is mapped as undulating land, nearly one-half as rolling and mixed undulating-rolling. Only 15,000 acres are mapped as hilly land. The undulating Whitewood topography has a more pronounced local or micro-relief than that of areas composed of lacustrine and resorted boulder clay deposits. Sloughs, podzolic depressions, low knolls and ridges are typical of the smoothest Whitewood areas.

Surface drainage is adequate on most Whitewood soils, but is somewhat excessive on steep rolling slopes and poor to very poor in local flat-depressional areas. Internal or soil profile drainage is satisfactory in most profiles. Restricted drainage is associated with poorly drained profiles on flat topography.

Glacial stones and boulders are present in all Whitewood areas. The best undulating soils are slightly to moderately stony (S_1 to S_2) but the bulk of the Whitewood soils are moderately to very stony (S_2 to S_3), particularly those on rolling topography. The undulating Whitewood soils between Fairholme, Glaslyn and Cater are very stony (S_3). Nearly 85 per cent. of the Whitewood soils are mapped as loam textures, with the remainder classified as light loam and clay loam.

The Whitewood Association consists of degraded black soils, that is, they are former grassland soils which, due to the effect of a later invasion of trees, have developed some features of the grey podzolic soil profile. The well drained upland profiles include Slightly, Moderately, and Strongly Degraded members. The two latter are most common. The usual profile variations produced by differences in local topographic position and drainage also appear in the Whitewood soils. However, Poorly Drained and Shallow Knoll members occupy only small areas.

Generalized descriptions of the more important Whitewood profiles are given below:

Whitewood Moderately Degraded Profile:

A_0 Horizon.—A thin layer of organic material (leaves, twigs, and partially decomposed plant residues) may be found on undisturbed profiles. This horizon has in many places been destroyed by fire.

A_1 Horizon.—Very dark grey; cloddy structure with the clods showing a platy cross-section and breaking readily into medium to thick platy aggregates (2″ to 4″ thick).

A_2 Horizon.—Greyish-brown; medium to thick platy structure, the brownish coloured plates showing grey porous spots. This structure crushes to a fine granular (powdery) form (4″ to 6″ thick).

B_1 Horizon.—Reddish-brown to dark brown; irregular columnar structure, the columns are not hard and smooth surfaced as in the typical hard columnar profile, but separate easily into hard irregular clods which break into hard nutty to angular fragmental aggregates (6″ to 10″ thick).

B_2 Horizon.—Yellowish-brown; columnar structure, less hard than B_1 (4″ to 6″ thick). In shallow profiles this horizon may be absent and the B_1 may show a slight development of the yellow-brown colour toward the bottom.

B(ca) Horizon.—Brownish-grey to grey; massive structure, breaking easily to soft granular condition; moderate to high content of lime carbonate (12″ to 18″ or more thick).

C Horizon.—Dark grey to medium grey, marked with yellowish, rusty, bluish-grey and light grey spots and streaks; massive to faintly laminated structure. This horizon consists of calcareous (limy) boulder clay, sometimes showing evidence of some water-sorting. Glacial stones are present in the parent material and throughout the profile above.

The Strongly Degraded Whitewood profile differs from the above profile in the following respects: The A_2 horizon has a light brownish-grey colour and the platy aggregates fall more easily into a loose, powdery, almost single-grained or structureless condition. The columnar structure of the B_1 horizon is only feebly expressed, and the soil breaks into hard angular fragments and nutty aggregates. Frequently no lime carbonate is encountered above the C_1 horizon or upper parent material.

Slightly Degraded upland profiles of the Whitewood Association have a black or nearly black A_1 horizon, a thin dark grey to very dark grey, faintly platy A_2 horizon. The B_1 has a large columnar (block-like) structure, in which the columns are well defined.

The profiles described above form a gradation between the black and the grey soils. The Slightly Degraded Whitewood profile is more comparable to the Oxbow Hard Columnar member, while the Strongly Degraded Whitewood profile is more like the dominant upland member of the Waitville Association.

The Poorly Drained member of the Whitewood Association is commonly found on the lowest arable land and also just outside local areas of depression or "bluff" podzols. The A_1 horizon is very dark grey in colour; the A_2 is dark grey to brownish-grey, and may contain some rusty spots and streaks. The B_1 horizon is very dark grey to very dark greyish-brown, mottled with rusty and yellowish flecks. This horizon has a massive structure and is hard and compact when dry. When wet it is very sticky. The lower horizons are mottled with rusty, yellowish, bluish-grey, grey, and other colours. Frequently this profile contains no lime carbonate to a depth of at least three or four feet below the surface.

The Shallow Knoll profile is most common on the rolling phases of the Whitewood soils. The A horizon is dark brown to greyish-brown, and frequently the A_1 and A_2 cannot be separated. The structure of the A horizon is cloddy with a faint platy development showing toward the bottom. The B_1 is bright brown or yellow-brown, of moderately hard columnar structure. The A and B_1 horizons are thin and the calcareous B_2-C horizons may occur at 8 to 12 inches below the surface.

The profile descriptions given above cover the typical Whitewood soils occurring on the undifferentiated calcareous boulder clay. The Whitewood soils occurring west of the Coteau Upland on the Turtleford Plain are developed on parent materials that appear to be intermediate in lime content between the undifferentiated boulder clay to the east and the relatively low lime deposits to the west. Hence the lime carbonate B(ca) horizon in these soils is deeper and less concentrated than in typical Whitewood soils. This is noticeable in mixed Whitewood-Waseca areas. From the practical point of view these Whitewood soils are comparable to the main Whitewood areas,

and in profile features above the lime layer they are essentially similar.

Whitewood soils are mapped as complexes with many other soils, including Oxbow, Waseca, Paddockwood, Pelly, Glenbush, Whitesand, Blaine Lake, Kamsack, and Waitville. Whitewood soils are easily distinguished from black soils on the one hand and grey podzolic soils on the other. They are distinguished from other degraded black soils such as Kamsack and Glenbush by parent material differences, and from Pelly soils by the fact that the latter have deeper profiles and have suffered less leaching.

Agriculture.—The Whitewood soils may be regarded as partially leached and hence poorer types of Oxbow soils. In conditions of texture, stoniness and topography these two associations are closely alike. The degree of podzolic leaching is the main factor in the differences in agricultural value. Slightly degraded Whitewood soils are practically equal in potential fertility to the Oxbow soils, and may be superior because of the better soil moisture conditions associated with degraded black soil areas. The dominant moderately degraded Whitewood soils are distinctly lower in nitrogen, organic matter, and phosphorus; and have a poorer structure. Depression podzols are often more frequent in Whitewood areas. As already indicated, the Whitewood soils centering on Glaslyn are very stony and this has had an adverse effect upon their agricultural development. The native cover of trees on all Whitewood soils is an additional handicap to cultivation.

Whitewood soils may be regarded as having similar crop adaptations to those of the Oxbow Association. Wheat and coarse grains are grown extensively, with smaller acreages of forage crops. It may be expected that Whitewood soils will require manure, fertilizers, and grass and legume crops to develop and maintain full productivity, and that the need for these will occur more quickly than on the richer black soils.

Wind erosion is rarely observed on Whitewood soils but slight to moderately severe water erosion has been noted on sloping land. Cultivated Whitewood soils of good topography are classified as poor to good agricultural types. The dominant moderately degraded loam soil is classified as fair land and is rated at 51. The less desirable light loam type is rated at 41 and the best Whitewood clay loam at 65.

HORSEHEAD ASSOCIATION

Description.—The Horsehead Association consists of degraded black loamy soils developed on relatively low lime boulder clay, chiefly of ground morainic origin. These soils are confined to the Beaver River Plain, and are located chiefly in the Barthel, Makwa, Loon Lake, Goodsoil and Beacon Hill districts. These soils are comparatively inextensive, occupying about 65,000 acres.

The soil landscape of the Horsehead Association is characterized by the "wavy" relief common to boulder clay deposits. The Horsehead landscape is not as rough, however, as that of the Whitewood. A mixedwood forest cover is also characteristic of the Horsehead soil areas. Moderate amounts of glacial stones are present and the

PLATE 19

Open muskeg with sphagnum and shrub vegetation on deep peat or bog soil.

Meadow-Bog complex, sedge and grass meadow fringed by willows, with spruce-willow cover on peat or bog soils in the background.

cultivated soils have a dark greyish to brownish-grey tinge, in contrast to the lighter grey colour of the grey podzol soils of the area. Fair to good agricultural development may be observed on the better Horsehead soils, but development is slow where Horsehead soils are mixed with stony and more strongly leached Loon River soils.

Most of the Horsehead soils are mapped on nearly level to undulating topography. About 10,000 acres are mapped as undulating-rolling and only 4,000 acres as rolling. Flat-depressional areas are common in the lowest land.

Surface drainage varies from poor to good. Undulating and rolling slopes are well drained, but the nearly level areas have slow drainage, and the depressions, unless connected with streams, have no natural surface drainage. Internal or profile drainage is satisfactory except in the soils occurring on flat-depressional topography.

Horsehead soils are generally less stony than the Loon River types. Slight to moderate stoniness (S_1 to S_2) are most common on Horsehead soils. The more stony areas occur in mixed areas of Horsehead and Loon River soils. The Horsehead Association includes Slightly, Moderately and Strongly Degraded members. Moderately and Strongly Degraded profiles are most common. Poorly Drained Degraded Black members occur on flat topography adjacent to undrained depressions. Local areas of Podzolic-Solonetzic profiles may also be encountered in the Horsehead Association.

Generalized descriptions of the more important member profiles are given below:

Horsehead Moderately Degraded Black Profile:

A_0 Horizon.—True A_0 rarely encountered, being either destroyed by fire or disturbed so as to form a mixed A_0 and A_1 horizon. (A_0 or A_0-A_1 0″ to 3″ thick).

A_1 Horizon.—Very dark brown to dark greyish-brown; loose granular structure, with faint platy development that is more pronounced with depth (3″ to 5″ thick).

A_2 Horizon.—Light brownish-grey; thick platy structure, moderately hard when dry (4″ to 6″ thick).

B_1 Horizon.—Dark brown to brown; columnar structure, breaking into flat segments which in turn break into hard, small nutty aggregates (8″ to 14″ thick).

B_2 Horizon.—Yellowish to greyish-brown, often with mottled colours indicative of incomplete drainage; massive structure—compact; frequently contains slight amounts of lime carbonate (4″ to 6″ thick).

B(ca) or C_1 Horizon.—Brownish-grey with lighter grey streaks; massive structure to faintly laminated; moderate lime carbonate content. It is difficult to determine whether this horizon should be classified as a calcareous (limy) B or the upper, slightly modified section of the parent material.

C_2 Horizon.—Dark grey, with whitish streaks; massive structure to laminated, breaking readily into short vertical aggregates, which also separate readily into well defined hard cubic and angular fragments; variable in lime carbonate content—fragments of lime-free shale or shale-like clay to light coloured streaks and spots of lime carbonate; frequent small stones, and occasional larger stones or boulders.

The more strongly degraded profiles have an A_1 horizon less than 3″ thick, and this is usually composed of a mixed A_0-A_1 horizon. The A_2 horizon is 7″ to 9″ thick and of a light ("ashy") grey colour. Other

horizons do not differ significantly from those described for the Moderately Degraded member. Podzolic Degraded-Solonetz profiles are characterized by an A_3 horizon of brownish-grey colour with a weakly developed columnar structure, breaking into thick plates. The B_1 horizon is very dark brown, hard and compact, with a columnar structure which breaks into very hard cubic aggregates. Solonetz profiles are also identified by the "wavy" contact between the A and B horizons—the line of the B_1 horizon being broken by tongues of the greyer coloured A horizon.

The Poorly Drained member of the Horsehead Association has a peaty A_0 horizon underlain by a dark grey A_2 horizon with some rusty layers or spots. The B_1 horizon is very dark grey to dark brownish-grey, mottled with rusty and yellowish colours. The lower B and C horizons are greyish in colour, mottled with rust, yellow and bluish-grey. The B horizons are usually wet and sticky.

The Slightly Degraded member is most likely to be encountered in mixed areas of Horsehead and Makwa soils. This member has a darker coloured A_1 horizon and a thinner A_2 than is found in the more highly degraded profiles.

Horsehead soils have been mapped as mixed areas or complexes with Loon River and Makwa soils. In Horsehead-Loon River complexes, the Horsehead soils may occur on boulder clay deposits and include Poorly Drained members. In Horsehead-Makwa complexes, the Horsehead soils may occur on boulder clay deposits occupying higher elevations within the Makwa soil areas. Horsehead soils are also mapped on modified or resorted boulder clay associated with the Makwa soils. The latter soils are much darker in colour and have undergone much less leaching or degradation than the Horsehead types.

Agriculture.—The potential fertility of the Horsehead soils varies with the degree of podzolic leaching. The lighter coloured, more highly leached members are low in organic matter, nitrogen and phosphorus and hence are regarded as only slightly superior to the Loon River Association. The Moderately Degraded members of the Horsehead Association are comparable to Whitewood profiles of similar texture and degree of leaching. Horsehead soils are rated from 42 to 59 on the basis of their potential suitability for grain production.

Since most of the Horsehead soils occur as mixed soil areas with Loon River and Makwa soils respectively, it is difficult to discuss the specific agricultural adaptations of this association. Wheat and coarse grains are the principal crops. It may be expected that the use of manure, fertilizers and the growing of grass and legume crops will be necessary for maximum production on these soils. This is more likely to be true of the Strongly Degraded members, but as time goes on fertility problems may also be expected to occur on the other Horsehead soils.

MAKWA ASSOCIATION

Description.—The Makwa Association consists of degraded black loamy soils developed on highly modified (water resorted) boulder clay, which in some places is associated with glacial lake deposits. The soils consist mainly of slightly degraded profiles. The

main area of Makwa soils is located between Loon Lake and Meadow Lake. Smaller areas of Makwa soils occur in the districts of Beacon Hill, Mudie Lake, Goodsoil, Flat Valley, and Meadow Lake. The total area of these soils is small—about 71,000 acres having been mapped.

The soil landscape of the Makwa soils is characterized by very gently undulating to flat-depressional topography, dark grey to very dark grey cultivated soils and a native cover of trees interspersed with grassy and meadow-bog areas. The settled areas are well developed agriculturally and apart from the wet lowlands there is little waste land.

The bulk of the Makwa soils occur on very gently sloping and undulating to flat topography. About 4,000 acres were mapped as roughly undulating and 1,000 as gently rolling. The latter represents a complex of the Makwa and Horsehead Associations.

The surface drainage of Makwa soil areas ranges from good to very poor. Sloping and undulating areas have satisfactory surface drainage, but the lowest areas have poor to no free surface drainage. Internal or soil profile drainage is moderately good in the better drained areas to poor in the lower areas adjacent to Meadow-Bog depressions.

Makwa soils are only slightly stony (S_1) and in many places the surface soils are stone-free. Stones are found most frequently in the subsoil.

Makwa soils are mapped as loam and clay loam with loam predominating.

The dominant members of the Makwa Association are the Slightly Degraded Black, the Degraded Black-Solonetzic, and the Poorly Drained profiles.

Generalized descriptions of the more important member profiles are given below:

Makwa Slightly Degraded Black Profile:

A_0 Horizon.—Thin leaf litter and partially decomposed organic material on better drained soils, frequently absent due to burning. In poorly drained locations a peaty surface layer is present (0″ to 2″ thick).

A_1 Horizon.—Nearly black to dark greyish-brown; soft cloddy structure, sometimes showing faint platy structure, and breaking to fine granular aggregates (6″ to 12″ thick).

A_2 Horizon.—Grey to brownish-grey; medium to thick platy structure; moderately hard when dry (3″ to 8″ thick).

B_1 Horizon.—Dark greyish-brown to brown (sometimes yellow-brown), hard columnar structure (8″ to 12″ thick).

B_2 Horizon.—Greyish-brown to yellowish-brown; columnar structure but less hard and compact than B_1; occasionally contains lime carbonate; very small stones occasionally present (4″ to 8″ thick).

B(ca) Horizon.—Light greyish-brown, sometimes mottled; massive structure, breaking to granular aggregates; glacial stones present; moderate to high content of lime carbonate; variable thickness, usually occurring about 36″ below the surface.

C_1 Horizon.—Mottled light greyish-brown modified (resorted) boulder clay; moderately calcareous (limy); glacial stones present; not easily distinguished from B(ca) horizon in the field.

PLATE 20

Trees and bush have been cut and piled and new breaking done on the cleared land.

Breaking cleared land with horses. In most districts the horse has been replaced by the tractor for this work.

The Strongly Degraded Makwa profiles have a thinner A_1 horizon than the above, ranging from 4" to 6" thick, and the greyish leached A_2 horizon is well developed. Such profiles are most common on the higher land south of the Makwa plain.

The Degraded Black-Solonetzic members are characterized by a thin A_3 horizon. In strongly leached (solod) profiles the A_2 horizon has a columnar structure which breaks into flat plate-like segments. The B_1 horizon varies from a compact, hard, columnar structured type to the round-topped columnar type associated with solodized-solonetz profiles. The B_1 horizon is also characterized by its "wavy" or undulating form when observed in road cuts.

The Poorly Drained member is characterized by a thin surface layer of peat, underlain by a thick, dark coloured mineral soil (A_1 horizon). The greyish A_2 horizon is usually thin—about 2" to 3" thick—and the B horizons show poorly drained features—greyish mottled colours, weakly developed structure, and usually a wet sticky condition.

The Makwa Association has been mapped as mixed soil areas or complexes with the Horsehead and Meadow Lake soils respectively. The largest area of mixed Makwa and Horsehead soils occurs southwest of Meadow Lake, along Morin Creek. The Makwa soils occupy the smoother, lower arable lands. Small areas of mixed Makwa-Meadow Lake soils occur east of Goodsoil.

Wet, depressional areas within Makwa soil belts are occupied by Meadow-Bog soils. These include Meadow, and Calcareous and Leached Shallow Peat (Half-Bog) profiles.

Agriculture.—The Makwa soils are among the best agricultural soils of the present surveyed area. The slightly degraded black profile with a thick A_1 horizon and clay loam texture, occurring on well drained, nearly level topography has been given a rating of 73. The light loam is rated at 56, and the other Makwa soils fall between 56 and 73.

Wheat, oats, and barley are the main crops on Makwa soils, but some forage crops, including alfalfa, are also produced. Lodging of grain crops and delayed maturity, in an area characterized by a short growing season, are adverse factors in Makwa soil areas. Such conditions are particularly likely to occur on the lower, more poorly drained soils. The clearing of dense forest cover is also a handicap in bringing Makwa soils under cultivation, but their high productivity justifies the effort involved. Makwa soils are closely similar to the Meadow Lake soils in their agricultural adaptations and problems. They are capable of producing a wider variety of crops than is generally grown, and probably the best utilization lies in a greater use of forage crops as compared with wheat. The possibility that the regular use of phosphatic fertilizers will assist in securing earlier maturity and stronger stands of crops should receive more attention.

PELLY ASSOCIATION

Description.—The Pelly Association consists chiefly of slightly degraded black loamy soils on modified (water-worked) boulder clay.

The main areas of these soils as mapped in the present survey are: between Paddockwood and Weirdale; north of Canwood; and around Witchekan Lake. Approximately 115,000 acres were mapped. The Pelly Association also occurs south of Township 48 where over 300,000 acres were mapped in former surveys.

The soil landscape of the Pelly Association is characterized by smooth ground morainic topography, a heavy stand of aspen, black poplar and occasionally spruce on uncultivated land, the dark grey colour of cultivated soils and the presence of few to moderate number of glacial stones.

Over 60 per cent. of the Pelly soils occur on very gently to gently undulating topography. Another 33 per cent. are mapped as mixed undulating-rolling and strongly undulating. This somewhat rougher topography and the small amount of rolling topography are usually encountered where Pelly soils occur as a complex with other associations.

Surface drainage is adequate on most Pelly soils, except in the level areas bordering depressions, which are characterized by slow drainage. Internal or profile drainage is satisfactory in nearly all of the Pelly soils, but moderate to poor drainage occurs in poorly drained member profiles.

Pelly soils, on the whole, are less stony than those developed on morainic deposits, such as the Whitewood and Waitville soils. Slight to moderate stoniness (S_1 to S_2) are most common.

Pelly soils consist of loam and clay loam textural types with the loams representing over two-thirds of the total acreage.

The Pelly Association consists chiefly of Degraded Black member profiles varying from Slightly Degraded to Moderately Degraded types. Poorly Drained and Thin or Shallow Knoll members occupy local areas of lowland and ridge and knoll respectively.

Generalized descriptions of the more important Pelly profiles are given below:

Pelly Slightly Degraded Black Profile:

A_0 Horizon.—Partially decomposed organic matter, often destroyed by fire or mixed with mineral soil below (1″ to 2″ thick).

A_1 Horizon.—Very dark grey to dark grey; granular-platy structure (4″ to 7″ thick).

A_2 Horizon.—Grey to dark grey; thick platy structure (3″ to 6″ thick).

B_1 Horizon.—Brown to faint yellow-brown; large blocky to faint columnar structure, breaking to granular aggregates (8″ to 14″ thick).

B(ca) Horizon.—Light yellow-brown to grey-brown; soft, massive to faintly laminated structure; moderate to high content of lime carbonate (6″ to 12″ thick).

C Horizon.—Grey, mottled with light grey, dark grey, and yellow; massive to laminated structure; small glacial stones present; moderate content of lime carbonate.

The Moderately Degraded Black profile has a thinner A_1 horizon than the above (2″ to 4″ thick). The A_2 horizon is greyish-brown to brownish-grey in colour and 5″ to 8″ thick.

Poorly Drained members usually have a thin peaty surface horizon. The mineral A horizons are very dark grey to dark grey with

some rusty spots and streaks. The lower horizons are dark brownish-grey mottled with rusty, yellow, and blue-grey colours. These horizons are usually wet and sticky.

The Shallow Knoll member has a relatively thin A_1 horizon, and the whole profile is shallower than those described above. Where the A_2 is well developed, the shallow Pelly profile is very similar to the Moderately Degraded member of the Whitewood Association.

Pelly soils are mapped as mixed soil areas, or complexes, with Whitewood, Paddockwood, and Kamsack soils respectively. A small area of mixed Pelly and Smeaton soils, and one of Pelly and Glenbush, have also been mapped. Local Meadow-Bog soils are common to Pelly soil areas.

Agriculture.—Pelly soils are highly fertile and due to the generally favourable soil moisture conditions they are also very productive. The chief drawback to their successful utilization is the short growing season and associated frost hazard, the Pelly soils in the Paddockwood and Witchekan Lake districts being particularly liable to frosts in the growing season. As a result, coarse grains, particularly oats, are safer crops than wheat. The introduction of earlier maturing varieties of wheat has, however, led to a greater use of this crop. Observations indicate that forage crops can be grown successfully on Pelly soils.

In addition to the climatic hazards, the heavy tree cover and the presence of wet meadow and peat areas have retarded the breaking and cultivating of these soils. Slight, and occasionally moderately severe water erosion have been observed on the rougher topography.

The best Pelly soils are the slightly degraded clay loam types of well drained, nearly level to very gently undulating topography. Such soils are rated at 72. Pelly loam of a similar nature and topography is rated at 63, while more severely leached soils are rated down to 57.

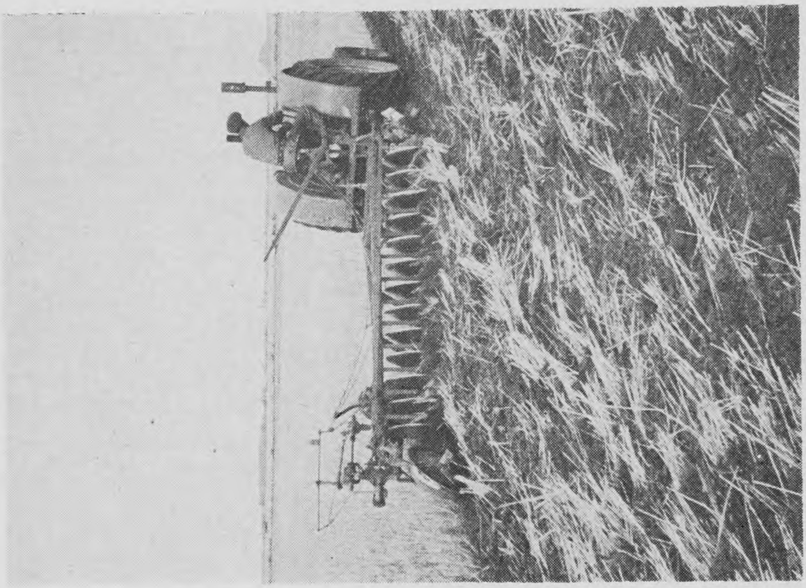
KELSEY ASSOCIATION

Description.—The Kelsey Association consists of degraded black soils on lake-modified boulder clay. The term "lake-modified" is used to denote modified boulder clay deposits occurring on the Saskatchewan Lowland within the bed of glacial Lake Agassiz. The boulder clay appears to be in part sorted by water and in part to be mixed with lacustrine deposits. Thus a rough banding may be frequently observed in the C horizon, while varying numbers of boulders occur at or near the surface, and small glacial stones are common in the parent material. As these deposits occur toward the northern edge of the glacial lake bed, it is possible that the material represents the combined action of the ice forming the shore line and the lake water in which lacustrine sediments were deposited. The term "lake-modified" will apply also to the parent material of the Garrick Association.

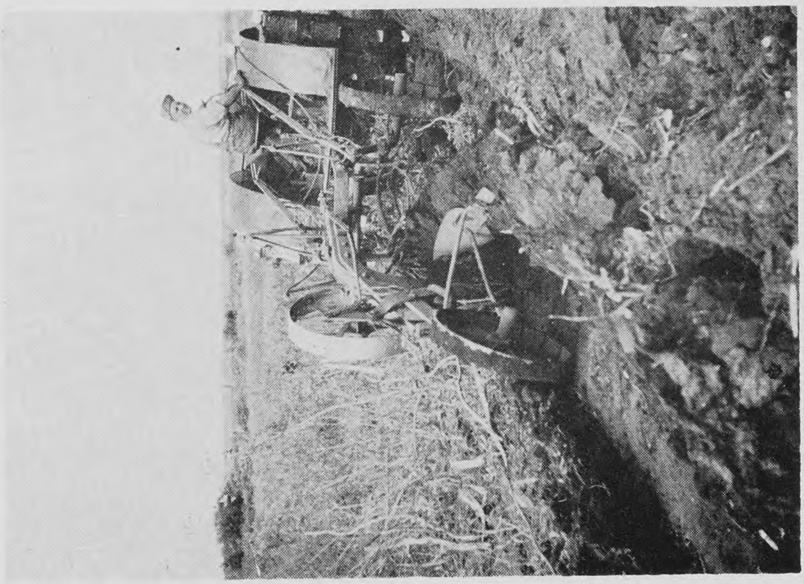
The Kelsey Association occurs chiefly between Weirdale and Whitefox, in the districts of Foxford, Shipman, Snowden, Choiceland, and Garrick. About 53,000 acres were mapped.

The soil landscape of the Kelsey Association is characterized by smooth, level to gently undulating topography, a heavy stand of tall

PLATE 21



Summerfallowing with one-way. Note excellent trash cover left to protect soil against erosion.



Breaking cleared land with tractor.

aspen, black poplar and spruce on uncleared land, and the greyish-brown colour of cultivated fields. The light yellow-brown (buff) colour of the B_2 and C horizons in road cuts, and occasional to fairly numerous glacial stones are also characteristic features of this association. Where sufficient clearing and breaking has been accomplished, the farms are well developed.

All of the Kelsey soils occur on nearly level to undulating topography, with local areas of flat-depressional land. The surface drainage was originally poor in the nearly level to flat areas. Changes resulting from settlement have improved the surface drainage, which is now adequate in most places with the exception of local undrained depressions. Internal or soil profile drainage is moderately good in most Kelsey soils except those in poorly drained areas.

Conditions of stoniness are variable. On the whole Kelsey soils are stone-free to moderately stony (S_0-S_2). Occasionally very stony patches occur (S_3) and these consist of large stones and boulders.

Kelsey soils are mapped as loam and clay loam, with a small amount of silty clay loam. Clay loam is the predominant texture.

The Kelsey Association consists chiefly of Moderately Degraded Black, Degraded Black-Solonetzic, Slightly Degraded Black, and Poorly Drained member profiles.

Generalized descriptions of the more important member profiles are given below:

Kelsey Moderately Degraded Black Profile:

A_0 Horizon.—Thin, and usually absent due to fires or cultivation.

A_1 Horizon.—Dark grey; cloddy, with platy structure evident (3" to 5" thick).

A_2 Horizon.—Grey-brown; soft, thin, platy (4" to 6" thick).

B_1 Horizon.—Light brown to yellow-brown (buff coloured); massive to faintly columnar in structure; breaking easily to medium granular aggregates (6" to 8" thick).

B_2 or C_1 Horizon.—Light coloured calcareous (limy). Regarded as C_1 horizon if indication of banded deposition is present.

C_2 Horizon.—Banded dark clayey and lighter coloured silty bands with small glacial pebbles. Lime carbonate present. Usually occurs at 26" to 36" below the surface.

The complex Degraded Black-Solonetzic member occupies flatter and usually slightly lower topographic positions than the above, but these two profiles occur as a close complex or intricate mixture.

Kelsey Degraded Black-Solonetzic Profile:

A_1 Horizon.—Dark greyish-brown; weak platy to granular structure (2" to 3" thick).

A_2 Horizon.—Medium grey; platy structure (4" to 6" thick).

A_3 Horizon.—Brownish-grey, or brown with light grey tinge; thick platy structure, hard when dry (1" to 3" thick).

B_1 Horizon.—Very dark grey; columnar structure, smooth and wax-like surfaces; breaking into hard coarse granular and nutty fragments.

The Slightly Degraded Black member is less common than the Moderately Degraded. The A_1 horizon of the Slightly Degraded profile is very dark grey, with a cloddy-granular structure which may show faint platiness (4" to 6" thick). The A_2 horizon is dark grey to dark greyish-brown (2" to 4" thick).

The Poorly Drained member may exhibit solonetzic features in the upper B horizon, but is distinguished chiefly by rusty-yellow-bluish-grey spots and streaks in the subsoil and to a lesser extent in the A horizon. A thin peaty surface horizon is present on undisturbed profiles.

Kelsey soils have been mapped as a complex with Garrick and Smeaton soils respectively. Local Meadow-Bog soils occur in wet depressions within Kelsey soil areas.

Agriculture.—The best Kelsey soils include the slightly to moderately degraded black clay loam profiles on smooth, well drained topography, with few stones present. The silty clay loam which is stone-free has the highest rating—75, with the clay loam at 70 and the loam at 62. Solonetzic soils of similar texture are rated about 8 points lower, and poorly drained members are rated below the better drained profiles.

Good crops of wheat, coarse grains, flax, and rape were observed on Kelsey soils. No wind or water erosion was observed at the time of survey. The heavy clearing of trees is a handicap to the full development of these soils, and where stones and boulders are numerous agricultural development is considerably below that of the better areas.

GLENBUSH ASSOCIATION

Description.—The Glenbush Association consists of degraded black coarse sandy and gravelly soils on glacio-fluvial deposits. These deposits consist of coarse textured out-wash, stream-eroded boulder clay and kames, all resulting from the rapid melting of glacial ice and the washing of glacial deposits by large volumes of water. In consequence of this, the fine material was largely removed and deposited elsewhere, leaving the coarser material behind. The Glenbush Association is, therefore, formed on parent deposits similar to those of the Whitesand and Bodmin Associations. The Glenbush Association was established to cover degraded black soils whose profiles represent various degrees of podzolic leaching between the non-leached, black Whitesand soils and the podzolized Bodmin soils.

The Glenbush soils are of widespread occurrence. The larger areas of these soils occur north of Prince Albert; along the south side of the Prince Albert National Park; along the east slope of the Coteau; near Spiritwood; and at Glenbush, Spruce Lake and Paradise Hill. 160,000 acres were mapped in this association.

The soil landscape of the Glenbush Association is characterized by the coarse sandy to gravelly nature of the surface soils and exposed road cuts. Small rounded stones (cobble) are common in many areas. The tree cover of aspen, black poplar and shrubs is not as dense and well developed as that on better textured soils. Similarly agricultural development is usually poorer than that of the better soil areas, and considerable unbroken land may occur.

Since Glenbush soils are found on a variety of glacio-fluvial deposits, the topography ranges from nearly level on sandy outwash plains to strongly rolling and hilly in kame deposits. About 50 per cent. of the soils were mapped as nearly level to undulating, and about 20

per cent. as gently to moderately rolling. The remainder are about equally divided between areas of mixed undulating-rolling and strongly rolling land.

Surface drainage is adequate in most Glenbush areas, except on local flat-depressional topography. Internal or soil profile drainage is excessive in most Glenbush profiles, except in the gritty loam types. The Glenbush soils are among the least drought resistant of the soils of the Transition Black-Grey area.

Conditions of stoniness are variable, the sandy loams being generally stone-free, while gritty and gravelly loams vary from slightly stony to excessively stony (S_1 to S_4); the latter are associated with eroded channels and although larger stones may occur, many of the stones are of small or cobble size, 3″ to 6″ in diameter. These are frequently so numerous that their complete removal is impracticable.

Gravelly subsoils and spots of surface gravel are common in Glenbush soil areas.

Glenbush soils are mapped as gravelly loam, sandy loam, and mixed gravelly and sandy loam. In some cases light loam has been mapped. This represents a gritty loam, as described under the Whitesand Association.

Glenbush soils are separated from the Whitesand on the basis of profile features that indicate some degree of podzolic leaching. The degree of leaching and the depth of the profile development vary with the texture and topography. On steep slopes, and also where much gravel and cobble are present, the profiles are weakly developed. Where a layer of gravel occurs close to the surface the profiles are thin.

The Glenbush Association includes Slightly Degraded Black, Moderately Degraded Black, and Poorly Drained member profiles. Moderately Degraded profiles predominate where the soils are well developed.

Generalized descriptions of the more important Glenbush profiles are given below:

Glenbush Moderately Degraded Black Sandy Loam, strongly rolling:

A_1 Horizon.—Dark grey, speckled with whitish silica grains; soft cloddy-platy, weakly developed (2″ to 3″ thick).

A_2 Horizon.—Brownish-grey to light brownish-grey; thin, soft platy structure, crushing to loose (structureless) sandy particles (3″ to 5″ thick).

B_1 Horizon.—Reddish-brown to reddish-yellow sandy clay; massive, hard and compact when dry, breaking into irregular, rough clods (4″ to 6″ thick).

B_2 Horizon.—Brownish-yellow; weak cloddy structure falling easily to loose structureless sand particles (8″ to 12″ thick).

C Horizon.—Yellowish loose sand to loamy sand; slight content of lime carbonate to lime-free; coarse gravel-pebble layers may occur under the B_2 so that true parent material is not always present.

Glenbush Moderately Degraded Black Sandy Loam on nearly level topography:

A_1 Horizon.—Very dark grey; soft, cloddy, with weak platy structure (3″ to 5″ thick).

A_2 Horizon.—Brownish-grey; hard, rough irregular platy structure when dry (5″ to 8″ thick).

B_1 Horizon.—Reddish-brown; large blocky structure, hard and compact (6″ to 9″ thick).

B_2 Horizon.—More yellowish than B_1 and only slightly compacted (6" to 8" thick).

C Horizon.—Yellowish; loose loamy sand; slightly calcareous to lime-free.

The Slightly Degraded Glenbush profile has a very dark grey, soft cloddy-granular A_1 horizon that is as thick or thicker than the A_2. The A_2 horizon is greyish-brown in colour, of platy structure, and the B_1 is brown in colour and of moderately hard columnar to irregular columnar structure.

Poorly Drained Glenbush profiles are associated with outwash deposits overlying heavier textured deposits. The A_1 horizons are dark coloured and the A_2 is dark grey and relatively thin. The B horizons are mottled with various rusty, yellowish and greyish shades; lime carbonate and possibly salts may be present.

The effects of gravel lenses occurring within the Glenbush profile are similar to those described under the Whitesand Association.

Glenbush soils are mapped as mixed soil areas or complexes with Whitesand, Shellbrook, Bodmin, Smeaton, Sylvania, Whitewood and Pine soils respectively.

Agriculture.—The Glenbush soils are among the poorer agricultural soils of the Province. They are low in drought resistance, relatively low in fertility, and are frequently associated with rough topography. Frequent gravel subsoils and cobbly-stony deposits are other undesirable features. These soils are thus similar to the Whitesand soils, but are rated still lower because they are partially leached or degraded, and because they have to be cleared of trees before they can be cultivated. The best Glenbush soils are the loamy types which are not excessively gravelly or stony and which occur on nearly level to undulating topography. Such soils are given a rating of 36, while the sandy loam of similar topography is rated 27. Very stony or gravelly types and all types on rolling to hilly topography represent very poor to non-arable soils. Agricultural development is poor on such types and it is difficult to see how it can be greatly improved. On the better Glenbush soils a system of farming that will return some organic matter is preferable to straight grain production.

SHELLBROOK ASSOCIATION

Description.—The Shellbrook Association consists of degraded black soils developed on sandy glacial alluvial-lacustrine deposits. These deposits consist mainly of fine and very fine sands, with a variable content of clay. In places the deposits may have been re-worked by the wind.

It is possible that a separation will ultimately be required between Shellbrook soils on loose loamy sands, and those on more compact sandy clay loam to sandy clay deposits. The textural variation is too great to allow the deposits to be classed as similar parent materials. The textural variation in the parent material is reflected in the textures of the surface soil horizons which range from light sandy loams to heavy sandy loams and sandy clay loams. The term sandy light loam, used on the present map, covers the heavier textured sandy soils, which in clay content are more comparable to loam textures. However, mechanical analyses have indicated there is over 50 per cent. of

sand in these soils and they should, therefore, be qualified by the term "sandy." From the practical standpoint of agricultural use, the light loam soils may be regarded as superior types of sandy loams.

The foregoing statements of sandy light loam textures apply also to the Meota, Sylvania, Whitefox, and La Corne Associations.

The main areas of Shellbrook soils of the present survey occur in the Shellbrook district; east of Prince Albert; and north of the North Saskatchewan River near the Alberta boundary. Many smaller areas of Shellbrook soils are scattered throughout the surveyed area. About one-quarter of a million acres were mapped in this association. Approximately one-half a million acres were mapped south of Township 48.

The soil landscape of the Shellbrook Association is characterized by stone-free sandy soils, a predominance of smooth undulating topography, and a light to medium cover of trees and shrubs. The cultivated soils have a dark grey-brown to brown colour, and the whitish limy spots characteristic of the black soils on till are absent in the Shellbrook areas. In most places the Shellbrook soils are well developed agriculturally. Some evidence of recent or former wind erosion may generally be observed.

Over 60 per cent. of the Shellbrook soils occur on undulating topography and only about 14 per cent. on rolling. The local topography or micro-relief is less pronounced than that associated with soils on boulder clay, such as the Whitewood and Waitville soils. Some flat to depressional areas occur in Shellbrook soil areas, but the frequent ridge and slough pattern is absent.

Surface drainage is adequate on nearly all Shellbrook soils, and internal or soil profile drainage is satisfactory in most places. Excessive drainage may occur in light textured profiles on well drained sites. Local low, poorly drained lands are characterized by Meadow-Bog soils.

Stones are rarely found in Shellbrook soils. Gravelly spots are likewise rare.

Textural classes include fine sandy loam, very fine sandy loam and sandy light loam. The latter, as already mentioned, represents heavy sandy loams and sandy clay loams.

The Shellbrook Association consists chiefly of Slightly to Moderately Degraded Black member profiles, the Slightly Degraded being most common. Local areas of Poorly Drained and Degraded Black-Solonetzic members also occur.

Generalized descriptions of the more important member profiles are given below:

Shellbrook Slightly Degraded Black Profile:

A_0 Horizon.—Partially decomposed organic matter, not always present (0"-1" thick).

A_1 Horizon.—Very dark grey to dark grey; cloddy-granular structure, sometimes faintly platy (4"-8" thick).

A_2 Horizon.—Pale brown to greyish-brown to brown; platy structure, faintly to well developed (3" to 5" thick).

B_1 Horizon.—Brown; irregular columnar structure (6" to 10" thick).

B_2 **Horizon.**—Yellowish to brownish-yellow; massive structure, falling easily to soft cloddy or powdery granular conditions (6" to 12" thick).

C_1 **Horizon.**—Yellowish-grey to yellow-brown; loose, structureless loamy sand to stratified sandy clay loam; lime-free to very slight content of lime carbonate. The separation of the B_2 and C horizons may be difficult to accomplish in some profiles.

The Moderately Degraded member shows a more advanced stage of podzolic leaching. The A_1 horizon is dark grey to greyish-brown. The A_2 horizon is very pale brown to brownish-grey and may reach a thickness of 8" to 10". The B_1 is light brown, with streaks of darker brown and has a large blocky structure which breaks to hard, nutty aggregates.

The Degraded Black-Solonetzic member is distinguished by a compact, hard columnar-structured B_1; a thin light grey A_3 horizon may also be present. The contact between the A and B horizons tends to form an uneven, wavy line.

The Poorly Drained member may have a peaty surface horizon, underlain by the greyish A_2 which is marked by rusty streaks and spots. The B_1 is a dark greyish-brown, mottled with yellow, rust and grey. Lower horizons are also mottled and usually wet.

Shallow Shellbrook profiles occur where the Shellbrook deposit is thin and overlies a heavier lacustrine or till deposit. Under these conditions the profile may appear to contain a calcareous (limy) B(ca) horizon. The lime carbonate layer, however, usually belongs to the underlying deposit and is really a D horizon.

Shellbrook soils are mapped as complexes with Meota, Glenbush, Dune Sand, Meadow-Bog, Whitefox, Sylvania, Whitewood, Weirdale, and other soils. Where sandy deposits overlie or are mixed with heavier textured deposits Shellbrook soils develop on the lighter materials and are distinguished by their sandy natures. In complexes of Meota and Shellbrook, the Shellbrook soils are distinguished by their leached A_2 horizons. In Sylvania-Shellbrook complexes, the Shellbrook soils appear darker and are less severely leached than the podzolized Sylvania soils.

Agriculture.—The Shellbrook soils are essentially similar to the Meota soils in agricultural adaptations and problems. They occur in areas where soil moisture conditions are generally more favourable and where the occurrence of drought and wind erosion is less frequent. In these respects Shellbrook soil areas are superior to Meota areas. On the other hand, the Shellbrook soils have all suffered some degree of podzolic leaching and are lower in organic matter, nitrogen, and other constituents than comparable Meota soils.

The Shellbrook sandy light loams which are only slightly degraded are the best agricultural types. Where they are underlain by heavier textured subsoils they are still more desirable and such soils carry ratings of over 60. The lighter fine sandy loam and the more strongly degraded profiles of all textures are rated lower, ranging down to 41. Where rough topography occurs the above ratings are subject to further deductions.

Wheat is the main crop grown on Shellbrook soils although considerable coarse grains and some forage crops are produced where

livestock are kept. In most years the production of crops is favourable, but in drier seasons yields may be low and soil drifting may become serious. The latter problem is particularly associated with areas where large scale wheat farming is practiced. Wind erosion was common in the 1930's and appeared again in 1948 and 1949. The control of soil drifting and the maintenance of organic matter are certain to become still more important as time goes on. The use of smaller fields or of strip cropping, together with a greater use of trash covers would seem to be required immediately to prevent the hazard of widespread drifting. The return of organic matter by the use of manure or the growing of grasses and legumes will also be necessary, particularly where the system of farming consists of continuous grain and fallow. It is important to remember that the fertility of the Shellbrook soils depends to a large extent on the dark coloured surface or A horizon. The removal of this layer by wind erosion, or the long continued removal of plant nutrients and organic matter by cropping and tillage will finally result in a soil of much lower potential fertility.

WHITEFOX ASSOCIATION

Description.—The Whitefox Association consists of degraded black sandy loam soils developed on alluvial deposits of the Saskatchewan and Torch Rivers. These deposits are typically fine textured sands where they form the Whitefox profiles, but the lower subsoils are frequently characterized by silty to clayey lenses. The Whitefox soils are largely confined to the district of Whitefox and more locally to an area north-east of Nipawin. They are inextensive with only about 53,000 acres having been mapped. Other local areas of these soils may be encountered on alluvial deposits of the Saskatchewan Lowland.

The soil landscape of the Whitefox Association is characterized by smooth, level topography, broken by occasional low terraces and shallow drainage channels. The surface cultivated soil is stone-free and has a greyish-brown colour. Most of the Whitefox soils are well developed agriculturally. Dense stands of moderate-sized aspen, black poplar, and shrubs occur on the uncultivated level land, and willows with occasional black spruce mark the bottoms of the channels and the local Meadow-Bog areas.

Most of the Whitefox soils occur on level topography with local areas of gently sloping to undulating topography along the terraces, drainage channels, and in the vicinity of the rivers. Flat to depressional topography occurs in the bottom of the drainage channels and in the Meadow-Bog areas.

Surface drainage is usually adequate except in the Meadow-Bog areas and in the drainage channels. Many of the drainage channels contain shallow undrained basins and frequently a chain of these depressions occurs, suggesting that the original drainage channel has been blocked. Internal or soil profile drainage is generally satisfactory for crop production, although the subsoils indicate conditions of moderately good to poor drainage. It is known that general drainage conditions have improved since settlement began, due to clearing and burning of the forest cover, cultivation of the arable land and the building of roads. The features indicative of poor subsoil drainage

PLATE 22

Drainage is essential in peaty areas and is the first step in successful reclamation.

This peat area has been burned in patches. Burning is not recommended as a general practice in reclaiming peat.

represent former drainage conditions rather than those existing today. However, in periods of heavy precipitation or following deep winter snowfall, poor drainage conditions may prevail temporarily and even result in a season in which the lower subsoils are excessively wet. The latter condition, in particular, is likely to develop where silty to clayey deposits occur immediately beneath the sandy subsoil of the Whitefox profile.

Whitefox soils are stone-free.

Whitefox soils are mapped as sandy light loam, very fine sandy loam, and fine sandy loam. The very fine sandy loam is the most commonly occurring texture, and the light loam is inextensive.

Most of the Whitefox soils may be described as Moderately Degraded Black profiles. The variations in profile features that indicate degrees of podzolic leaching are less marked than the variations indicative of differences in drainage conditions. The best drained Whitefox profile must be regarded as only moderately well drained when compared to the soils of the well drained uplands. However, as already stated, the profile features that suggest poor subsoil drainage represent former drainage conditions and most of the Whitefox soils appear to be well drained agricultural types, except during excessively wet periods.

Generalized descriptions of the more important member profiles of the Whitefox Association are given below:

Whitefox very fine sandy loam:

A_1 Horizon.—Very dark grey; loose to faintly platy structure (2″ to 4″ thick).

A_2 Horizon.—Greyish-brown to pale brown; platy structure easily crushed to loose powdery condition (4″ to 6″ thick).

B_1 Horizon.—Brownish-yellow, slight to moderate compaction, sandy clay loam texture, grades into B_2 or C.

B_2 or C Horizon.—Yellowish, some rusty streaks, no lime. (B_1 and B_2 12″ to 18″ thick.)

D Horizon.—Greyish, loose, very fine sand, slightly calcareous; may be only a thin layer and underlain by a mottled sandy to silty alluvium.

Whitefox Poorly Drained very fine sandy loam:

A_1 Horizon.—Very dark grey; platy structure (3″ to 4″ thick).

A_2 Horizon.—Dark grey to greyish-brown; platy structure (4″ to 5″ thick).

B_1 Horizon.—Mottled, rusty-yellow-greyish; not very compact.

D Horizon.—Poorly drained, sandy-silty to clayey deposit.

The Very Poorly Drained member has a peaty surface, unless destroyed by fire or cultivation. The A and B horizons are mottled rusty-yellow-bluish-grey and are generally moist to wet.

Whitefox soils occur as a complex with Nipawin, the latter representing heavier textured soils on alluvial deposits. Whitefox soils also occur as a complex with La Corne, Carrot River and Meadow-Bog soils respectively. The La Corne Association represents more strongly podzolized sandy soils, which have thicker and lighter coloured A_2 horizons than those of the Whitefox Association. The Carrot River soils are also sandy textured but are not degraded and in most places are limy to the surface or in the upper B horizon.

Agriculture.—The Whitefox soils are used mainly for wheat production with smaller acreages sown to coarse grains. The best soils

are the sandy light loam and very fine sandy loam types of the better drained areas. Such soils are rated with the Shellbrook soils of similar texture. The Whitefox soils are associated with more favourable moisture conditions than most of the Shellbrook soils but this advantage is partially offset by the fact that the Whitefox soils are more strongly leached than the dominant Shellbrook types. Whitefox sandy light loam is rated at 56 and the very fine sandy loam at 50. The fine sandy loam is rated at 41.

The use of manure and fertilizers and a greater diversity of crops to include more legumes and grasses would seem to be desirable practices for Whitefox soil areas. Some wind erosion has occurred and is likely to become more serious under the prevailing system of grain farming. The control of erosion and the maintenance of soil organic matter are important.

NIPAWIN ASSOCIATION

Description.—The Nipawin Association consists of degraded black loamy soils on alluvial deposits associated with the Saskatchewan River in the basin of Lake Agassiz. These soils occur chiefly in the Nipawin district, on the east and south side of the river. It is possible that small areas, adjacent to the river, may occur further west. In the present survey about 50,000 acres were mapped in the Nipawin-Lost River-Whitefox areas.

The soil landscape of the Nipawin Association is characterized by nearly level topography, broken by occasional terraces and shallow depressions; the latter appear to be sections of former stream channels. The cultivated soil has a distinctive light brown colour and is free from stones or gravel. Nipawin soils are well developed agriculturally, and the original tree cover has been largely cleared off. Occasional small areas of greyish depression podzols also occur.

Nipawin soils occur chiefly on smooth nearly level topography with areas of gently sloping to gently rolling land associated with the terraces and former stream channels. Some rolling and mixed undulating-rolling topography occurs on terraces in the Lost River district.

Surface drainage is adequate except in the undrained depressions within the stream channels. Internal or soil profile drainage is generally satisfactory for crop production although the subsoils indicate moderately good to poor drainage conditions. The statement on drainage made under the Whitefox Association may be applied to the Nipawin soil areas. Thus it is known that drainage conditions have improved since settlement began, due to clearing, burning, the cultivation of arable land and the building of roads. The soil features indicative of poor subsoil drainage represent former conditions rather than those existing today. However, during wet summers or following deep winter snowfall, conditions of poor drainage may prevail temporarily or may even result in a season in which the lower subsoils are excessively wet. Such conditions are particularly likely to occur in the heavier textured Nipawin soils, including the solonetzic members, and on the depressional topography of the drainage channels and depression podzols.

Nipawin soils are free of stones and gravel.

Nipawin soils are mapped chiefly as loam and clay loam, which frequently occur as a textural complex or mixture. Local spots of clay occur in the clay loam areas and a small amount of light loam was mapped.

The Nipawin Association consists chiefly of Moderately Degraded Black soils, and the profiles range from moderately well drained to poorly drained types. There are also local areas of solonetzic soils.

Generalized descriptions of the more important member profiles of the Nipawin Association are given below:

Nipawin Well Drained Profile:

A_1 Horizon.—Dark grey to dark greyish-brown; granular to weak platy structure (3″ to 6″ thick).

A_2 Horizon.—Greyish-brown to brownish-grey; thick platy structure (6″ to 12″ thick).

B_1 Horizon.—Brown; irregular columnar structure, breaking to small nutty or coarse granular aggregates; compact and heavier textured than A horizon (4″ to 12″ thick).

$B_2(C_1)$ Horizon.—Yellowish-brown to yellow, usually sandy clay loam; massive structure; compact. This horizon is sometimes absent (0″ to 6″ thick).

D Horizon.—Variable—grey, loamy very fine sand to light grey, silty clay loam, occasionally heavy clay; calcareous.

Nipawin Poorly Drained Profile:

A_1 Horizon.—Very dark grey; cloddy-platy structure (3″ to 5″ thick).

A_2 Horizon.—Light brownish-grey; platy structure, easily broken down (4″ to 6″ thick).

B Horizon.—Mottled rusty yellow; massive structure, moderately compact; becomes more yellowish with depth (10″ to 14″ thick).

D Horizon.—Silty clay loam to clay; calcareous.

The Solonetzic member of the Nipawin Association is characterized by a heavy textured, compact B_1 horizon with a columnar structure that breaks to hard cubic and angular fragmental aggregates. The solonetzic B_1 is further characterized by its undulating "wavy" form—coming close to the surface in one place, then dipping to form a deeper subsoil, and rising closer to the surface again farther on.

Strongly Degraded Nipawin soils may be occasionally encountered, in which the A_1 horizon is only one to three inches thick, and the A_2 is thicker than average and of a light brownish-grey to pale brown colour.

Nipawin soils occur as a complex with Whitefox soils, the latter representing sandy loam soils on alluvial deposits.

Agriculture.—The Nipawin soils are highly fertile and, with the favourable topography and high proportion of arable land, are among the most productive soils of the surveyed area. Wheat is the main crop and is grown under a large scale mechanized system of farming. Smaller acreages of coarse grains, forage, and special crops such as rape, are also grown. The Nipawin soils are heavier textured and contain more nitrogen and organic matter than the Whitefox soils. The Nipawin soils are, therefore, given a higher rating, the clay loam being rated at 69 and the loam at 63. These ratings apply to the

better drained, moderately degraded profiles. Lower ratings are given to poorly drained and to solonetzic soils.

Very slight wind erosion has been observed on Nipawin soils, and slight water erosion is occasionally present on the sloping and rolling lands associated with terraces.

KAMSACK ASSOCIATION

Description.—The Kamsack Association consists of degraded black silty to clayey soils on medium heavy glacial lacustrine deposits. In the present survey the main areas of Kamsack soils occur between Nipawin and Weirdale; north-west of Prince Albert; north of Shellbrook; north of Spiritwood; east of Turtleford. About 120,000 acres were mapped. Kamsack soils also occur south of Township 48 where about 180,000 acres were mapped in former surveys.

The soil landscape of the Kamsack Association is characterized by nearly level to moderately undulating topography. Where rolling topography occurs it usually represents a mixture of Kamsack and other associations, although a few broadly rolling areas of Kamsack soils have been mapped. The Kamsack landscape is further characterized by the dark to medium grey colour of cultivated soils, few to no stones, and well developed farms. The cultivated areas are bordered by medium to heavy stands of aspen and black poplar with occasional spruce. Depression Podzols and Meadow-Bog areas are also typical.

Over two-thirds of the Kamsack soils occur on nearly level to undulating topography, and another one-sixth on mixed undulating and rolling or roughly undulating topography. Only about 11,000 acres have been classified as rolling.

Surface drainage is satisfactory on most of the Kamsack soils, but may be somewhat excessive on steeper slopes, permitting some loss of water by run-off. Slow surface drainage is associated with flat-depressional areas bordering meadow-bog depressions. Internal or soil profile drainage is adequate in the medium textured Kamsack soils on well drained upland topography, but is somewhat restricted on lower, flatter positions and in heavy textured subsoils. Poor to very poor internal drainage is associated with Kamsack soils on flat-depressional topography bordering undrained basins.

Kamsack soils are typically stone-free except for occasional small glacial stones occurring in the subsoils. Stones and occasional boulders are more common on the borders of Kamsack soil areas particularly where the underlying glacial till is close to the surface. Stones and boulders are also common in mixed areas of Kamsack soils and soils developed on glacial till. Kamsack soils are stone-free to moderately stony (S_0 to S_2).

Kamsack soils have been mapped in medium to medium heavy textures, including loam, silty loam, clay loam, silty clay loam and clay. Clay loam and loam textures predominate in the present area and represent about 90,000 acres, or roughly 75 per cent. of the total acreage of Kamsack soils. Clay and silty clay textures are relatively inextensive, occupying about 5,000 acres. The remainder of the Kamsack soils consist of silty textures.

Member profiles of the Kamsack Association consist chiefly of Moderately Degraded and Slightly Degraded Black soils. Poorly Drained Black and Strongly Degraded profiles also occur as less extensive members.

Generalized descriptions of the more important member profiles are given below:

Kamsack Moderately Degraded Black Profile:

A_0 **Horizon.**—Partially decomposed organic matter (0″ to 2″ thick).

A_1 **Horizon.**—Dark grey clay loam or silty clay loam; granular-platy structure (1½″ to 3″ thick).

A_2 **Horizon.**—Brownish-grey clay loam or silty clay loam; thick platy structure (4″ to 7″ thick).

B_1 **Horizon.**—Brown to dark greyish-brown clay to heavy clay; faint columnar structure falling into coarse granular to nutty aggregates, hard and compact (8″ to 12″ thick).

B_2 **Horizon.**—Yellow-brown clay; coarse granular structure, less compact than B_1 (4″ to 8″ thick).

B(ca) Horizon.—Yellowish-grey silty clay with high content of lime carbonate; massive to faintly laminated, falling easily to friable granular aggregates (6″ to 12″ thick).

C_1 **Horizon.**—Yellowish-grey silty clay; moderate content of lime carbonate; laminated structure. This horizon grades into the C_2 horizon which is characterized by varved clays—that is, alternating bands of yellowish-grey silty clay and darker, heavier clay. Where the lacustrine deposit is thin, the C_1 or B(ca) horizon may be underlain by a stony-pebbly re-sorted boulder clay deposit (D horizon).

Kamsack Slightly Degraded Black Profile:

A_0 **Horizon.**—Organic matter layer, very thin or absent.

A_1 **Horizon.**—Very dark grey; faintly platy structure, breaking easily to granular aggregates (8″ to 12″ thick).

A_2 **Horizon.**—Medium grey to dark grey; platy structure, thin or absent (0″ to 2″ thick).

B_1 **Horizon.**—Greyish-brown with dark staining at the top; columnar structure (6″ to 12″ thick).

B_2 **Horizon.**—Yellowish-grey (yellow-brown when moist); massive to faintly laminated (12″ to 24″ thick).

The Poorly Drained member usually occurs under a layer of partially decomposed and raw peat, unless fire has destroyed the organic material (2″ to 4″ thick). The A horizon is very dark grey with a platy structure. The B_1 horizon is also very dark grey, but mottled with bluish-grey and rusty streaks and spots; it is a heavy compact soil with massive structure. The B_2 horizon is yellowish-grey to bluish-grey and faintly laminated, containing lime carbonate. The C_1 horizon is a mottled grey, blue, rusty, poorly drained horizon containing lime carbonate, and is usually wet.

The Strongly Degraded member is more like a podzolic profile than a degraded black soil. In the present reconnaissance survey these strongly degraded soils were classified as Kamsack, since their occurrence in relatively small scattered areas did not justify mapping them as a separate association. The profile is characterized by a thin A_0 horizon where not destroyed by fire. The A_1 horizon is very thin —about ½″ to less than 1″ thick, and grey in colour. The A_2 horizon is 6″ to 10″ thick and pale brown to light brownish-grey in colour. The B_1 is brown in colour, heavy textured, and compact.

Occasionally complex Degraded Black-Solonetzic profiles are encountered in the Kamsack soils. These are characterized by a greyish, platy structured A_3 horizon, and a compact heavy textured B horizon that occurs at varying depths from the surface, producing the undulating or "wavy" form associated with solonetzic soils.

Shallow profiles occurring on knolls and upper slopes of rolling topography are recognized by their thinner horizons and by the presence of stones and pebbles which mark the underlying boulder clay.

Kamsack soils occur as a complex or mixture with Whitewood, Pelly, Paddockwood, and Weirdale soils respectively. Kamsack soils are distinguished from the Whitewood, Paddockwood and Pelly soils by the fact that the latter are developed on stony parent materials—boulder clay or glacial till. Paddockwood soils are further distinguished by the presence of lime carbonate and the absence of podzolic leaching in the A horizon. Weirdale soils are distinguished by their calcareous non-podzolic features, although, like the Kamsack, they are developed on glacial lacustrine deposits.

Agriculture.—The predominant types of Kamsack soils are highly fertile and the well drained level to undulating areas are among the most productive agricultural lands of the area. Wheat is the main crop, but oats and barley are also grown, and in the eastern section of the surveyed area some alfalfa and rape are also produced. Soil ratings range from 65 for Kamsack loam to 81 for Kamsack silty clay. Lower ratings are applied to the more strongly degraded profiles and to the complex Degraded Black-Solonetzic type.

The Kamsack soils on roughly undulating to rolling topography are rated lower than similar profiles on the more level lands. In rolling areas the soils are more subject to loss of water by run-off and to the accompanying erosion. Crop growth is less uniform and cultivation is more difficult and also more costly.

Slight wind erosion occurs locally on Kamsack soils, while on the rougher topography, referred to above, slight to moderately severe water erosion is fairly common. The control of water erosion is, therefore, an important problem on the farms so affected.

TISDALE ASSOCIATION

Description.—The Tisdale Association consists chiefly of slightly degraded black soils developed on heavy textured glacial lacustrine deposits. The heavy clay types are associated with lower and flatter topography than the majority of the Tisdale soils. It is almost certain that the Tisdale heavy clay soils will ultimately be classified as a separate association. For the present these soils are classified as Tisdale because their profiles are similar in essential features to the established Tisdale soils.

In the present survey the Tisdale soils are found on the Saskatchewan Lowland in the area between Nipawin and Pontrilas and also north of Carrot River. A few small areas were mapped near the Torch River south of Choiceland. About 121,000 acres were mapped in the Tisdale Association. South of Township 48, in the area covered by Soil Survey Report No. 12, Tisdale soils occupy over half a million acres.

The soil landscape of the Tisdale Association is characterized by the nearly level to smoothly undulating topography, the dark grey colour of cultivated soils, the absence of stones and the presence of a well developed tree cover on unbroken land. Lower areas are characterized by marshy and shallow peat depressions. The farms are well developed and indicate a highly productive soil.

The Tisdale soils occur chiefly on level to undulating topography and in the present area no rolling topography is associated with these soils. Flat to depressional topography is associated with the heavy clay soils and to a lesser extent with the medium textured soils.

Surface drainage is fair to good in areas of medium textured soils of level to undulating topography. Slow surface drainage occurs in flat to depressional areas. Internal or soil profile drainage is adequate in the medium textured soils on undulating topography, but somewhat restricted in the lower subsoils of profiles occurring on level topography. Poor to very poor internal drainage is associated with the heavy clay soils on flat to depressional topography. The original drainage conditions in the flat to depressional areas had to be improved by the construction of drainage ditches before clearing and breaking could be carried on. With the improvement in surface drainage, it follows that some improvement would occur in the profile drainage, particularly in the surface horizons. In heavy textured soils, however, the removal of excess surface water would not necessarily lead to an improvement in subsoil drainage such as occurred in the Whitefox and Nipawin soils. Hence, in the Tisdale heavy clay and clay areas the presence of wet, poorly aerated subsoils and the temporary flooding and waterlogging of the whole profile during wet seasons remains a problem to the farmer.

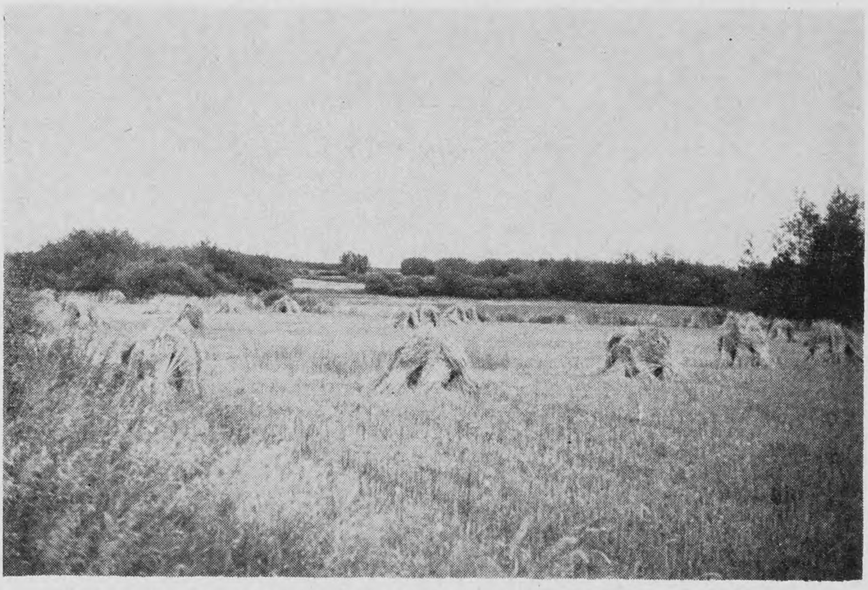
Tisdale soils are typically stone-free, and stones are only encountered near creeks and rivers or where the underlying boulder clay is exposed.

Tisdale soils are mapped as clay loam, silty clay loam, silty clay, clay and heavy clay. In the present area the clay texture predominates, occupying over 60 per cent. of the total acreage of Tisdale soils. The heavy clay soil which, it was stated, may ultimately form a new association, occupies about 20,000 acres. The clay loam occupies a similar acreage and the remaining small acreage is composed of silty clay loam and silty clay.

Member profiles of the Tisdale Association consist chiefly of Slightly Degraded Black soils, with some Moderately Degraded and Poorly Drained members. Moderately Degraded profiles are most likely to occur on higher well drained positions and in the medium textured soils. Poorly Drained members are common on flat-depressional topography and predominate in heavy clay areas. Complex Degraded Black-Solonetzic profiles may also occur in the Tisdale Association, but were not encountered so frequently in the present surveyed area as in the main belt of Tisdale soils to the south. A special condition exists in the present area where Tisdale soils border or are mixed with Weirdale or Nipawin soils. Here the Tisdale profiles are shallow so that only the A and upper B horizons are developed from Tisdale parent material. The lower subsoils consist of

PLATE 23

Forest meadows are useful for pasture, but in most places the areas of open land are small.



Patchy cultivation is common in the early stages of development of wooded areas.

variable textured alluvial material, sometimes highly calcareous. Such profiles are regarded as shallow Tisdale soils overlying deposits of a different nature.

Generalized descriptions of the more important member profiles of the Tisdale Association are given below:

Tisdale Slightly Degraded Profile:

A_0 **Horizon.**—Partially decomposed organic matter, frequently absent due to burning (0" to 2" thick).

A_1 **Horizon.**—Very dark grey; coarse granular to faint platy structure (5" to 8" thick).

A_2 **Horizon.**—Dark grey; thick platy structure, breaking to granular aggregates (2" to 4" thick).

B_1 **Horizon.**—Dark greyish-brown; coarse granular to nutty structure; heavier textured than A_2 (8" to 12" thick).

B_2 **Horizon.**—Brownish-grey silty clay; massive to faintly laminated, falling readily into friable granular aggregates; moderately high content of lime carbonate (12" or more thick).

C **Horizon.**—Banded (varved) lacustrine deposit consisting of dark grey clay and yellowish silty material; moderate content of lime carbonate.

Tisdale Moderately Degraded Profile:

A_0 **Horizon.**—Where present, as described above.

A_1 **Horizon.**—Dark grey; platy structure (2" to 5" thick).

A_2 **Horizon.**—Brownish-grey; thick platy structure (4" to 6" thick).

B_1 **Horizon.**—Dark greyish-brown to dark brown; hard nutty to angular fragmental structure; heavy textured and more compact than B_1 of slightly degraded member.

B_2 **Horizon.**—May be essentially similar to B_2 described above or may consist of yellowish-brown, lime-free horizon between the B_1 and the horizon of lime carbonate accumulation.

Tisdale Poorly Drained Profile:

A_0 **Horizon.**—Peaty layer of mixed raw and partially decomposed organic material (4" to 12" thick).

A_1 **Horizon.**—Very dark grey clay to heavy clay; platy structure, breaking to granular aggregates (4" to 6" thick).

A_2 **Horizon.**—Grey with rusty tinge; platy structure (1" to 3" thick).

B_1 **Horizon.**—Dark bluish-grey, with rusty and light greyish spots and streaks; hard compact heavy clay of massive structure, breaking to large hard angular fragments when dry (8" to 12" thick).

B_2 **Horizon.**—Dark grey to grey, mottled with rusty-yellow spots and streaks; massive structure, slight to moderate lime carbonate content.

C **Horizon.**—Poorly drained, wet, mottled, heavy textured lacustrine deposit.

A particular type of profile associated with the heavy clay soils is characterized by a "shotty" structure—which consists of rounded smooth aggregates of the size of pellets to that of peas. These shot-like particles are found in the natural profile but they also seem to persist in the cultivated soil. A description of one of these profiles is given below:

A_0 **Horizon.**—Partially decomposed organic material or peat (3" thick).

A_1 **Horizon.**—Very dark grey clay, shotty structure as described above (4" thick).

A_2 **Horizon.**—Grey clay; platy to shotty structure (4" thick).

B_1 **Horizon.**—Greyish-brown heavy clay; massive when wet, when dry shows faint columnar structure, hard and compact (10" thick).

B_2 **Horizon.**—Greyish heavy clay (silty) mottled with rusty and yellow and whitish streaks; moderate content of lime (10" thick).

C **Horizon.**—Greyish, mottled heavy lacustrine clay, calcareous.

Tisdale soils have been mapped as complexes with Weirdale, Arborfield and Meadow-Bog soils. In Weirdale complexes the Tisdale profiles are shallow and the lower horizons are similar to those of the Weirdale soils. Arborfield-Tisdale complexes occupy flat, poorly drained areas.

Agriculture.—Most of the Tisdale soils are highly fertile and productive, and the well drained medium to medium heavy, slightly degraded soils carry the highest ratings—ranging from 70 to 78. The heavy clay soils are rated at 64, with further deductions if they are poorly drained. The agricultural value of these heavy soils is adversely affected by the associated poor drainage, the problem of developing desirable structure (or condition of good tilth) and the hazard of frost.

Tisdale soils are used principally for grain production, with wheat being the main crop. However, this soil association is well suited to the production of coarse grains and forage crops, including legumes. Malting barley is a special crop that is grown successfully in some districts. The ability of these soils to grow forage crops and coarse grains makes them desirable for livestock production.

Erosion is not a serious factor on the Tisdale soils of the present area.

BEAVER RIVER ASSOCIATION

Description.—The Beaver River Association consists chiefly of moderately degraded black soils developed on silty clay glacial lacustrine deposits. These deposits are similar to those on which the Meadow Lake Association has developed, and the Beaver River soils may be regarded as degraded Meadow Lake types. It is assumed that the Beaver River soils were originally similar to the Meadow Lake soils, but that due to invasion of a forest vegetation they became partially leached or degraded. The Beaver River Association is mainly confined to the districts of Meadow Lake and Dorintosh. Smaller areas occur elsewhere, mostly in association with Meadow Lake soils. The Beaver River Association is very inextensive, only 36,000 acres having been mapped.

The soil landscape of the Beaver River Association is characterized by nearly level to undulating topography, the absence of stones, the dark grey colour of cultivated fields, the heavy stand of black and white poplar on uncultivated lands, and Meadow-Bog vegetation on flat to depressional areas.

The Beaver River soils occur mainly on gently undulating topography.

Surface drainage is satisfactory on the Beaver River soils of undulating topography. Slow to poor and very poor drainage is associated with the flat-depressional areas, but these are occupied by Meadow and Bog soils. In general, the Beaver River soils occupy slightly higher or slightly more sloping portions of the glacial lake bed where surface drainage is adequate. Internal or profile drainage is satisfactory in most Beaver River soils, except in the complex Degraded Black-Solonetzic profiles, and in those profiles bordering Meadow-Bog areas.

Beaver River soils are typically free of stones and gravel. A few stony areas occur on the higher elevations, where the lake clay deposit is thin and the underlying boulder clay is exposed in road cuts, or may be brought up by deep ploughing.

The Beaver River soils are mapped chiefly in clay loam and loam textures. About two-thirds of the total acreage was classified as loam. A small area south of Meadow Lake consists of clay loam and clay.

The Beaver River Association consists chiefly of Moderately Degraded Black profiles. In addition, local areas of complex Degraded Black-Solonetzic members occur, and Poorly Drained members may be found on lower, flatter topographic positions. It is probable, however, that some of the Poorly Drained profiles could be classified as Meadow Lake types, since under conditions of poor drainage podzolic leaching or degradation may be restricted and the profile may be more comparable to a poorly drained black soil.

Generalized descriptions of the Beaver River member profiles are given below:

Beaver River Moderately Degraded Profile:

A_0 Horizon.—Partially decomposed organic layer (1" thick).

A_1 Horizon.—Dark grey to dark brownish-grey; platy structure (3" to 5" thick).

A_2 Horizon.—Light greyish-brown to brownish-grey; platy structure (4" to 8" thick).

B_1 Horizon.—Brown to dark brown; cloddy-columnar to irregular columnar structure, breaking to nutty aggregates (8" to 12" thick).

B_2 Horizon.—Light brown to yellow-brown; massive to faint columnar structure; lime-free to sometimes slightly calcareous (8" to 12" or more thick).

B_3 Horizon.—Yellowish-brown to yellowish-grey; massive structure; moderate content of lime carbonate; the B_3 horizon is not always easy to separate from the C_1 horizon.

C_1 Horizon.—Yellowish-grey to grey; faintly laminated; moderate content of lime; sometimes may be regarded as B(ca) horizon where a B_3 horizon cannot be identified.

C_2 Horizon.—Banded (varved) light grey and dark grey-brown silty clay; moderately calcareous (limy).

The Beaver River solonetzic member is similar to the Meadow Lake solonetz profile, except that the former has a thinner and greyer coloured A_1 horizon and a thicker A_2.

The Beaver River soils have been mapped as complexes with Meadow Lake, Dorintosh and Meadow-Bog soils respectively. In combination with Meadow Lake soils the Beaver River soils occupy somewhat higher and better drained land. In mixed areas of Dorintosh and Beaver River, the latter soil is distinguished by its darker colour in the cultivated fields, due to the presence of a thicker and darker A_1 horizon.

Agriculture.—The Beaver River soils are good agricultural types, and along with the Meadow Lake and Makwa they represent the best soils of the Beaver River Plain. Agricultural development of Beaver River soils, like that of the Meadow Lake, is favoured by the smooth topography and absence of stones. However, the Beaver River soils are rated below the Meadow Lake types of similar texture, largely because they are partially leached and are lower in nitrogen and

organic matter. The Beaver River clay loam is rated at 70 and the loam at 60. For grain production the Beaver River soils compare favourably with the Meadow Lake soils, due probably to better drainage and the earlier maturity associated with the degraded black soils in a region where frost is a hazard. As suggested under the discussion of the Meadow Lake Association, the higher rating of the Meadow Lake soils is justified when a variety of crops, including legumes and grasses are grown, rather than the prevailing system of grain production.

Wheat, oats, and barley are the most commonly grown crops on Beaver River soils.

Slight water erosion has been observed, but the heavy clearing costs on uncultivated land and the maintenance of soil fertility are the major problems.

PADDOCKWOOD ASSOCIATION

Description.—The Paddockwood Association consists of highly calcareous loam to clay loam soils on modified (resorted) boulder clay, occurring within the forest region. As stated previously, the presence of considerable lime carbonate, the incomplete drainage and possibly the relatively recent age of the soils have combined to prevent the full development of a leached grey (podzol) profile. On the other hand, although the Paddockwood soils bear some resemblance to the Yorkton soils of the Black Soil Zone they are not true black soils. In addition to having developed under a wooded cover, the Paddockwood soils differ from the Yorkton in that the A horizons are lower in organic matter, have a more pronounced platy structure, and are lighter in colour.

The Paddockwood Association occurs chiefly on the Shellbrook-Meath Park plain bordering the Saskatchewan Lowland and on the Debden Plain north of Shellbrook. The larger areas of Paddockwood soils are found in the districts of Henribourg, Paddockwood, Canwood and Polwarth. Paddockwood soils also occur near Mildred; in the Witchekan Lake basin near Spiritwood; and around Midnight and Stony Lakes. About 116,000 acres were mapped in this Association.

The soil landscape of the Paddockwood Association is characterized by very gently undulating to flat depressional topography, the medium to dark greyish colour of the cultivated soil which at first glance appears to be leached or degraded, and the lighter coloured very limy subsoil exposed in road cuts and sometimes on cultivated knolls. A moderate number of glacial stones is also characteristic of this association.

A dense growth of poplars, willows and various shrubs occupies most of the uncultivated land. Agricultural development generally ranges from fair to poor, some of the Paddockwood soils being associated with areas having a distinct frost hazard, which at times is a serious handicap to the farmer. Local Meadow and Bog soils occupy flat-depressional lands.

The topography of the Paddockwood soil areas is chiefly nearly level to very gently undulating. 96,000 acres were mapped in this range of topography, and the remainder as roughly undulating or as

mixed undulating and rolling. The latter topography is generally associated with complexes or mixtures of Paddockwood and other associations. Local areas of flat to depressional topography occur within the Paddockwood soils.

Surface drainage of Paddockwood soils ranges from good to poor, the latter condition being associated with the Paddockwood soils bordering flat-depressional areas. Surface drainage is adequate on the higher sloping land. Interior or profile drainage is chiefly moderately good to very poor. In most places lime carbonate is present in the A or surface horizon, indicating that the internal movement of soil water has not been sufficient to leach the profile. Poor internal drainage is associated with the flatter and lower lands.

Glacial stones are common and some clearing is usually required. On the whole, however, the Paddockwood soils are not seriously handicapped by the presence of stones, and slight to moderate stoniness (S_1 to S_2) prevails.

Loam textures predominate in the Paddockwood Association, approximately 85,000 acres having been mapped as loam. About 16,000 acres were mapped as clay loam and a somewhat smaller acreage as light loam. The light loam textural class covers a loamy soil which contains sufficient very coarse sand and small gravel to give the soil a "gritty" feel, although the proportion of such coarse material is not great enough to place the soil in a sandy loam class.

The member profiles of the Paddockwood Association consist chiefly of Wooded Calcareous Earth and Rendzina-like profiles. The term "wooded calcareous earth" is used to denote a profile similar in general character to the black calcareous earth, but which has developed under a wooded vegetation and whose mineral A horizon is lower in organic matter than the corresponding black soil horizon. High nitrogen and organic matter contents in Paddockwood soils are associated with peaty surface horizons or with A_0-A_1 horizons in which the organic material of the peat has been mixed with the mineral soil.

Shallow Knoll and Poorly Drained members also occur. From upland to depression, Paddockwood Shallow Knoll, Wooded Calcareous Earth, Rendzina-like, and Poorly Drained Calcareous members may be encountered, together with local representatives of the Meadow-Bog complex, including Meadow, calcareous Shallow Peat, leached (podzolic) Peat and Depression Podzol profiles. In a reconnaissance soil survey it is not possible to separate Paddockwood soils from intermixed Meadow-Bog types.

Generalized descriptions of the more important member profiles are given below:

Wooded Calcareous Earth Profile:

A_{0-1} Horizon.—Very dark grey; soft, cloddy-granular structure; mixed peaty and mineral matter; may be absent due to fires or A_0 may not develop on best drained sites (0" to 2" to 3" thick).

A_1 Horizon.—Dark grey to grey loam; platy to cloddy structure; soft and friable when moist, but moderately hard and compact when dry, particularly at lower depths; calcareous (limy) at the surface or at some point within this horizon (8" to 14" thick).

B_1 Horizon.—Greyish-brown to yellowish-brown; soft cloddy structure, easily crushed to granular aggregates; high content of lime (3″ to 6″ thick).

B(ca) Horizon.—Light yellowish-grey; massive, falling easily to granular structure; very high content of lime. It may be difficult to separate this horizon from the underlying C_1 (about 8″ thick).

C Horizon.—Yellowish-grey sandy clay loam to gritty clay loam water-worked till; massive to faintly laminated structure; high lime content.

Rendzina-like Profile:

A Horizon.—Grey to medium-dark grey loam; platy structure, breaking to irregular soft-cloddy and granular aggregates; moderate content of lime (6″ to 10″ thick).

B(ca) Horizon.—Light grey to faintly yellowish light grey; massive structure, soft and falling easily to fine granular aggregates; very high content of lime carbonate (6″ to 12″ thick).

C Horizon.—As above.

The Shallow Knoll profile is characterized by a thin, greyish A horizon, containing lime carbonate (3″ to 4″ thick). The B horizon is also thin and light coloured and has a high content of lime.

The Poorly Drained member in uncultivated areas has a thin peaty surface layer, and a thick dark grey, moderately calcareous A horizon. The B horizon is greyish, mottled with rusty yellowish and bluish-grey spots and streaks; a moderately high to high content of lime carbonate occurs in this horizon, and sometimes soluble (alkali) salts may also be present. The C horizon is a greyish mottled, poorly drained calcareous till.

Some soils included with the Paddockwood Association have undergone slight leaching so that no lime remains in the A horizon and very little in the upper B. When a compact, lime-free B_1 horizon has developed it is considered that the profile belongs to the degraded type of soil formations, and as such is not classified as a member of the Paddockwood Association.

Paddockwood soils have been mapped as complexes with a number of other associations. Most commonly Paddockwood soils are found as a mixture or complex with Weirdale, Pelly, Meadow-Bog and Whitewood soils respectively. Weirdale soils are closely similar to Paddockwood in general profile character, but are separated on the basis of parent material, the Weirdale soils occurring on silty glacial lacustrine deposits which are stone-free and chiefly of level to flat-depressional topography.

Agriculture.—The better drained calcareous earth loam and clay loam soils are classified as moderately good to good agricultural soils with ratings of 58 to 61. The Paddockwood light loams are regarded as fair soils with a rating of 49. These lighter types are more droughty, less uniform, and somewhat more stony than the loams and clay loams.

Paddockwood soils are used principally for grain production. A considerable acreage is devoted to oats, particularly where frost is a definite hazard.

The agricultural development of Paddockwood soils has been handicapped by the frost hazard, the necessity of clearing trees before cultivation and the presence of much wet, poorly drained Meadow-Bog land. Drainage has improved through the combined effects of

land clearing, road construction and the disappearance of open water from lakes and marshes. Slight water erosion has been observed in Paddockwood soil areas more particularly on roughly undulating to gently rolling topography where Paddockwood soils are mixed with degraded soils of other associations.

WEIRDALE ASSOCIATION

Description.—The Weirdale Association consists of highly calcareous medium to medium heavy soils on silty glacial lacustrine deposits. These soils occur in the forest region under both wooded and peat vegetation.

The Weirdale Association occurs chiefly on the Saskatchewan Lowland and the adjacent Shellbrook-Meath Park plain, with smaller areas occurring on the Debden Plain and in the Witchekan Lake Basin. About 207,000 acres were mapped in this association. Approximately 23,000 acres were mapped as clay and silty clay textures, chiefly in the eastern section of the area. Because of the heavier nature of the parent material the clay types should be regarded as a separate association, but in the present reconnaissance survey they were included with the Weirdale. The general profile characteristics of the clay and loamy types of Weirdale soils are essentially similar.

The soil landscape of the Weirdale Association is characterized by nearly level to depressional topography and a wooded to peaty vegetative cover. The peaty areas are associated with willows and black spruce. The absence of stones and the light coloured calcareous subsoils exposed in road cuts and ditches are also characteristic of this association. The older cultivated areas of Weirdale soils are well developed and the crops and improvements on the farms reflect the high productivity of the soil. In the extreme eastern section of the surveyed area the Weirdale soils are heavy textured and occur on flat, poorly drained land. Here drainage ditches are a familiar sight, as land has to be drained before it can brought under cultivation.

The topography of Weirdale soils is typically smooth and much of it is nearly level to flat. Only about 13,000 acres were mapped as mixed undulating and rolling and about 18,000 acres as rolling. This rougher topography represents soil areas composed of Weirdale and some other soil associations. In such areas the Weirdale soils occupy the low, flat to depressional positions.

Surface drainage of Weirdale soils varies from fair to very poor. Surface drainage is slow at best and in the undrained areas it is necessary to provide drainage ditches to remove excess water. Internal, or soil profile drainage is likewise only fair to very poor. In most places lime is present in the surface horizons and the subsoils invariably show evidence of wet, poorly drained conditions. The original cover of peat on many Weirdale soils is also an indication of their poorly drained state.

Weirdale soils are typically free of stones and gravel, and where stones do occur they are generally associated with a complex of Weirdale and other soil associations. Glacial stones may sometimes be encountered in the subsoils of Weirdale profiles, where thin lacustrine and peat deposits overlie boulder clay.

Weirdale soils have been mapped in a wide range of textures. As previously indicated the clay and silty clay types, occupying about 23,000 acres, should ultimately be classified as a separate association. The main areas of Weirdale soils consist of loam to silty clay loam textures. Almost 100,000 acres are mapped as loam, about 55,000 acres as clay loam and a considerably smaller acreage as silty loam and silty clay loam. Approximately 18,000 acres are mapped as light loam. In connection with the Weirdale soils formed under a peaty surface, the texture of the soils as determined in the field is greatly influenced by the stage of decomposition of the peat. Where the peat is well decomposed into a dark coloured uniform organic material, it has the effect of masking or hiding the stickiness of the clay particles giving the soil a smooth, light-textured "feel" when moistened and rubbed between the fingers and thumb. Such soils have a higher clay content than the field texture would suggest. They are more nearly like muck soils than ordinary mineral soils.

The member profiles of the Weirdale Association include Wooded Calcareous, Rendzina-like, and Peaty Calcareous profiles.

Generalized descriptions of the more important Weirdale member profiles are given below:

Weirdale Wooded Calcareous Profile:

A Horizon.—Dark grey to very dark grey; granular structure; high organic matter content; lime-free at surface, but calcareous (limy) at about 6 inches (6″ to 10″ thick).

A-B Horizon.—Dark grey; irregular large blocky-thick platy structure; moderate lime content (8″ to 12″ thick).

B_1 Horizon.—Dark greyish-brown; irregular columnar structure, breaking easily to cloddy aggregates; moderate lime content (4″ to 8″ thick).

B(ca) Horizon.—Yellowish-grey; soft massive, crushing easily to fine granular aggregates; high content of lime; this horizon grades into the upper parent material and it may be difficult to identify when moist (6″ or more thick).

C Horizon.—Yellowish-grey, somewhat mottled; some indication of banding; high lime content; may contain occasional small glacial pebbles.

The above profile represents the best drained and most highly developed Weirdale profile. It is not very extensive, being confined to areas of very gently undulating topography, chiefly on the Meath Park-Shellbrook Plain.

Weirdale Poorly Drained Rendzina-like Profile:

A Horizon.—Medium grey to grey; soft cloddy-granular structure; moderate lime content (8″ to 10″ thick).

B(ca) Horizon.—Mixed dark and light grey, mottled with rusty, yellowish and bluish-grey; massive structure, breaking to cloddy-granular aggregates; high lime content (8″ to 12″ thick).

C Horizon.—Mottled brownish-grey, rusty, bluish-grey colours; massive to faintly banded or laminated structure; high lime content.

Weirdale Peaty Calcareous Profile:

A_{00} Horizon.—Raw (undecomposed) peat; originally present on much of the flat-depressional land, but rarely found after cultivation is established (0″ to 12″ thick).

$A_{0\text{-}1}$ Horizon.—Mixed highly decomposed (muck-like) peat and mineral matter; very dark grey to nearly black; granular structure, loose and fluffy; may also contain peat-ash from burning of the former surface peat; slight to very high lime content (8″ to 12″ thick).

A_1 Horizon.—Very dark grey; granular-platy structure; very slight to moderate lime content, or may be lime-free (8″ to 10″ thick).

B Horizon.—Grey to light grey; massive structure; soft and friable; high lime content (4" to 8" or more thick).

C Horizon.—Yellowish-grey, mottled with rusty streaks; silty lacustrine deposit with high content of lime.

The variation in the lime carbonate content of the A_{0-1} and A_1 horizons appears to depend upon the presence or absence of peat ash. The undecomposed and unburned peat does not contain free lime carbonate. The peat ash, however, effervesces vigourously when treated with weak muriatic acid (HCl) thus indicating the presence of carbonates. These may consist of magnesium and potassium carbonates as well as calcium carbonate.

Weirdale soils have been mapped as complexes or mixed soil areas with Tisdale, Kamsack, Paddockwood, Shellbrook, Whitesand and Meadow-Bog soils respectively. Weirdale soils are distinguished from Paddockwood soils by the fact that the latter are developed on stony boulder clay deposits. Tisdale and Kamsack soils differ from Weirdale in having partially leached or degraded A horizons in which no lime carbonate is present, together with lime-free B_1 horizons. The most difficult separation is that involving mixed areas of Weirdale, Meadow and Bog (Peat) soils. The well defined Weirdale profiles grade into those which may be classified as Bog soils. As a guide it may be stated that Weirdale soils should be characterized by thick mineral A horizons of a granular to platy structure, whereas the Meadow and Bog soils tend to have somewhat thinner A horizons with less well developed structure and more evidence of wet, poorly drained conditions. Bog soils, in addition, have a surface layer of undecomposed peat, which may or may not be present on Weirdale soils.

Agriculture.—The medium to medium-heavy textured Weirdale soils which are at least moderately well drained represent some of the best agricultural soils in the surveyed area. The Weirdale clay and silty clay loam types are classified as excellent soils with ratings of 83 and 77 respectively. The loam and clay loam are good agricultural soils, with ratings of 63 to 70. The Weirdale light loam is rated at 54.

Weirdale soils need to be cleared of trees, and in some areas to be drained, before they can be cultivated. The preparation of peaty areas is also a problem. Once cleared and broken, however, the soils are highly productive. There is little waste land and the nearly level topography ensures the maximum retention of water received through precipitation. The high organic matter content and the favourable structure of the Weirdale soils also favour their use as arable land.

Weirdale soils are used principally for grain production, including both wheat and coarse grains. Special crops such as field peas and rape are also grown. Forage crops, although grown only to a small extent, appear to be equally well adapted to these soils.

Water erosion is rare, but slight wind erosion has occurred on some Weirdale soils. The prevention of serious wind erosion is essential to the continued high productivity of these soils. An unknown factor is the ultimate effect of drainage upon the moisture reserves of the soil, particularly in the lighter textured soils.

PLATE 24

Grains are important as cash and feed crops throughout the area. This crop of wheat is on degraded black soil.

Alfalfa is a soil conserving crop and an excellent fodder. It is also used as a cash crop where seed production is satisfactory.

CARROT RIVER ASSOCIATION

Description.—The Carrot River Association consists of fine textured sandy loam soils developed on calcareous sandy alluvial deposits, which are underlain at an average depth of 5 or 6 feet by heavier textured alluvial-lacustrine or boulder clay deposits. The original vegetation of the Carrot River soils consisted chiefly of peat and wooded peat, varying from less than one foot to three feet in thickness. In their original state the Carrot River soils would be classified as shallow peat (half-bog) soils associated with light textured mineral deposits. At the present time, however, these soils are largely under cultivation or being prepared for cultivation, and the original peat cover is modified or destroyed. The Carrot River Association is, therefore, classified with the wooded calcareous group and in most instances the original peat surface has been burned and the ash and more decomposed peat mixed with the mineral soil. Local areas of peat may still be found, but these are almost certain to disappear with the further agricultural development of the Carrot River Association.

The Carrot River Association is confined to the eastern section of the present surveyed area, chiefly in the district around the town of Carrot River. A few small areas occur north of Whitefox. About 95,000 acres were mapped in this association.

The soil landscape of the Carrot River Association is characterized by a uniform flat topography, broken only by muskeg depressions, occasional low sandy ridges and knolls, and near the Carrot River by stream channels and the river valley. Most of the Carrot River soil area appears as an open cultivated plain with occasional patches of black spruce, tamarack and willow swamp. Drainage ditches, often located along the roadways, are a feature of this landscape. The cultivated soils have a greyish appearance, modified in places by brown to nearly black peaty material and patches of whitish ash from burned peat. Stones are absent except where drainage ditches reach the underlying till. A high proportion of cultivated land and well developed farms are also characteristic of this association.

The topography of the Carrot River soil areas is nearly level to flat-depressional. While the surface appears to be flat or level, most of the land has a very gentle slope to the Carrot and Petaigan Rivers. Local hummocky topography is produced either by the presence of low sandy ridges and knolls or by the remnants of the original peat deposit standing above the cultivated mineral soil.

Surface drainage of the Carrot River Association was originally very slow to absent, and drainage ditches had to be constructed before settlement could proceed. Most of the Carrot River soils now under cultivation can be regarded as having satisfactory surface drainage, except in the lower flat-depressional areas that are still covered by a peat and wooded vegetation. These local bog areas are still undrained. Internal or soil profile drainage was originally poor to very poor, but like the surface drainage has been improved by artificial means. Most of the cultivated soils now have good internal drainage except at lower depths where heavy textured deposits occur. The depressions and other peaty areas are still poorly drained internally. The effect of the artificial drainage in improving the original soil drainage is

seen immediately in the ability of the soil to grow good crops. The mottled colours and other features of the profile that indicate poor drainage are still present as features inherited from the past history of the soil's formation. Temporary conditions of poor drainage occur in wet seasons.

Carrot River soils are free of stones and gravel in the cultivated layers. Occasional glacial stones may be seen in ditch banks and road cuts where the underlying glacial till has been exposed.

Carrot River soils have been mapped in fine sandy loam to loamy sand, very fine sandy loam and sandy light loam textures. Over one-half of the total acreage is classified as light loam, which represents heavier textured sandy loams to sandy clay loams. About one-third of the total acreage is classified as very fine sandy loam. Most of the Carrot River soils are, therefore, composed of the finer (heavier) textured sandy loams.

The member profiles of the Carrot River Association are not as sharply defined as those of most soil associations. There is relatively little development of a mineral profile and the modifications of the original soil through drainage, clearing, burning and cultivation make it necessary to recognize cultivated members in addition to the original types. In fact, the greatest differences in Carrot River profiles are due to the activity of man in changing the original environment. The members of this association include first the original shallow peat profiles, varying in thickness of peat and to a slight extent in the depth of leaching as indicated by the depth at which lime carbonate occurs; and in addition modified member profiles representing the cultivated soils. These modified profiles vary in the peat, ash and lime carbonate content of the surface horizons, but at lower depths do not differ significantly from the original profile. The statement on the carbonate content of the Weirdale soils also applies to the Carrot River soils.

Generalized descriptions of the member profiles are given below:

Carrot River Shallow Peat Profile:

A_0 Horizon.—Brown, raw (undecomposed) peat; smooth, greasy "feel" when wet; light, fluffy, granular condition when dry; this horizon may contain some mineral matter; in some places no decomposed peat may be present, while in other sites a definite layer of partially decomposed peat is present (1" to 6" thick).

A_2 Horizon.—Greyish sandy loam; massive, soft, falling easily to granular or loose structureless condition; usually lime-free (8" to 12" thick).

B-C Horizon.—Mottled yellow-rusty-grey sandy material; massive, soft and falling easily to granular aggregates; moderately high to high content of lime; this horizon grades into the C horizon below and may be difficult to separate.

C Horizon.—Similar to description of B and where separated is characterized by more rusty and bluish-grey colours and evidence of stratified deposition.

D Horizon.—Not always encountered, but in general occurs at depths of 5 to 6 feet, and occasionally at 3 feet. Grey, calcareous silty clay to heavy clay of alluvial or lacustrine origin; occasionally modified (resorted) boulder clay forms a D horizon.

Carrot River Modified Peat Profile:

$A_{0\text{-}1}$ Horizon.—Mixed partially decomposed peat, peat ash, and mineral soil; dark grey with streaks of whitish ashy material; loose, fluffy, granular condition; moderate to high content of lime (2" to 8" thick).

A_2 **Horizon.**—Yellowish-grey sandy loam; massive to faint platy structure; no lime present (12" to 18" thick).

B-C Horizon.—Mottled yellowish-rusty-bluish-grey sandy material; moderately high lime content.

D Horizon.—If present, as described above.

In some places the original peat surface has been completely destroyed or perhaps was not present originally, so that the surface soil consists of a yellowish-grey, loose, structureless sandy loam to loamy sand. Such soils are subject to wind erosion.

Carrot River soils are mapped as complexes or mixed areas with Whitefox, La Corne, Pine and Meadow-Bog soils respectively. The first three mentioned associations occupy sandy ridges occurring at higher elevations than the adjacent Carrot River soils. For this reason the Whitefox, La Corne and Pine Associations occupy well drained positions and have developed a leached (podzolic) profile. In Carrot River-Meadow-Bog complexes the Meadow-Bog soils occupy slightly lower or flatter topographic positions in which drainage is very poor.

Agriculture.—The main area of Carrot River soils shown on the map is well developed agriculturally. When the land has been drained and cleared it is practically all arable. The best Carrot River soils are those of very fine sandy loam to sandy light loam texture in which considerable decomposed peat and at least some partially decomposed peat is present. Such soils have a dark surface colour and granular structure. They are rated from 56 to 60. The lighter textured fine sandy loam and loamy sand profiles are rated at 41 to 50.

The Carrot River soils are adapted to a wide variety of crops. At the time of survey, wheat followed by oats and barley were the main grain crops. Rape and some field peas were also grown. Only small scattered acreages of legume and grass crops were observed. Under this system of growing seed crops for sale off the farm, no provision is made to maintain soil organic matter and structure or to remove the hazard of soil drifting. As the peat is destroyed or is disturbed and modified by tillage the mineral soil assumes a more loose and sandy character. Wind erosion of moderately severe proportion has occurred and it is very probable that it will increase in both extent and severity. The presence of leached sandy soils on ridges and knolls unprotected by peat intensifies the erosion hazard. Such soils act as focal points from which soil drifting may spread to adjacent Carrot River soils.

In addition to the erosion hazard, continuous grain cropping and the destruction of peaty material will also lower the organic matter and nitrogen content of the soil. The results of chemical analysis show a wide range in the nitrogen content of Carrot River soils, and the amount of nitrogen is directly related to the amount of peaty material present. Some of the surface horizons of the light coloured sandy soils are very low in nitrogen and organic matter. It is considered that a wider and more frequent use of legume and grass crops will be necessary if Carrot River soils are to remain productive and if wind erosion is to be controlled. Owing to the flat topography and porous nature of the soil, water erosion is not a problem.

The Grey and Brownish-Grey Podzolic Soils

Grey and Brownish-Grey Podzolic soils of the present surveyed area are represented by the following associations:

Waitville	Pine	Smeaton
Loon River	Sylvania	La Corne
Bodmin	Arborfield	Dorintosh
	Garrick	

The Smeaton, La Corne and Dorintosh Associations are classified as Brownish-Grey Podzolic and the remaining associations as Grey Podzolic soils.

The Grey and Brownish-Grey Podzolic soils occupy the Boreal Forest section of the surveyed area and form the dominant upland soils of northern Saskatchewan. Within the surveyed area these soils form a broad belt across the more northerly portions of the soil map, and also occur as islands and outliers within the Black-Grey soil belt. The Grey Podzolic soils occur throughout the area but the Brownish-Grey soils occur chiefly in the eastern section between Smeaton and Carrot River.

The Podzolic soils are formed mainly under a wooded or tree cover and a cool sub-humid climate, with a relatively short growing season. Muskeg and Meadow-Bog soils are associated with the Grey Podzolic Zone and lakes and permanent streams are more numerous than in the less humid sections of the province.

The Grey Podzolic soils are characterized by well developed light grey, leached (podzolized) A_2 horizons, and by A_1 horizons which are very thin or absent. The Brownish-Grey soils have thicker and darker A_1 horizons and the greyish A_2 horizons have a distinct brown tinge. In both types the B horizons are heavier in texture than the A horizons, although the difference is less marked in podzolized sand profiles. The podzolic soils range from very slightly acid to moderately acid in reaction (pH 6.8 to pH 5.0).

Profiles occurring in the Grey Soil Zone are illustrated in Figure 7.

WAITVILLE ASSOCIATION

Description.—The Waitville Association consists of grey podzolic loam and clay loam soils developed on undifferentiated boulder clay. The term "undifferentiated" is defined under the section on the Oxbow Association.

The Waitville soils are the most extensive of all associations mapped in the present survey. They occur in all areas except the extreme eastern section east of Nipawin, and in the Meadow Lake area. Nearly 800,000 acres, or over 12 per cent. of the total area, were mapped in the Waitville Association. About one and three-quarter million acres of Waitville soils were mapped in former surveys south of Township 48.

The soil landscape of the Waitville Association is characterized by a medium to heavy cover of mixedwood forest vegetation, including aspen, black poplar, white spruce, birch, willows and numerous shrubs. In most places the present cover is dominated by aspen and

represents secondary growth, since very few areas, if any, have escaped forest fires or logging operations. As a result it is probable that the proportion of spruce and birch is lower than in the climax forest. It is significant that these species are more numerous in protected areas of forest reserves and parks and on islands in lakes.

The Waitville landscape is also characterized by the "wavy" surface associated with morainic deposits—a succession of knoll and ridge, intermediate slope, and depressional or kettle topography. Glacial stones and boulders are common. Cultivated soils are grey to light grey in colour. Agricultural development is fair to poor and considerable uncultivated land occurs, particularly in stony or rough areas.

The topography of the Waitville Association ranges from very gently undulating to strongly rolling, most of it showing the morainic wave-like form already referred to. About 300,000 acres were mapped as undulating, 280,000 acres as gently to moderately rolling, and 20,000 acres as strongly rolling. About 185,000 acres were mapped as mixed undulating-rolling topography.

Surface drainage is adequate in nearly all Waitville soil areas, but may be somewhat excessive on steeper slopes of rolling areas. Local areas of flat to depressional land have poor to no surface drainage. Internal or soil profile drainage is satisfactory in loam and clay loam soils on well drained positions. Waitville light loam soils, representing gritty to somewhat gravelly textures, are excessively drained in the A horizons. Impeded profile drainage occurs in heavier textured soils on flat topography.

Glacial stones and boulders are always present in Waitville soils. The better soils are moderately stony (S_2), but on the average the Waitville Association is moderately to very stony (S_2 to S_3). Excessively stony (S_4) areas occur in some of the rough rolling areas and along stream channels and the borders of lakes. Local areas of gravelly subsoils occur in rolling areas and particularly in light loam areas.

Waitville soils are mapped as loam, clay loam, and light loam textures. Loam textures are most common, representing over one-half of the total acreage. Clay loam textures occupy the next largest acreage.

The dominant member profile of the Waitville Association is the Upland Podzolic. Shallow Knoll profiles occur on steep upper slopes in areas of rolling topography. Moderately to Poorly Drained profiles occur on low flat topography.

Generalized descriptions of the more important member profiles are given below:

Waitville Thick Upland Podzolic Profile:

A_{00} Horizon.—Twigs, leaves (leaf litter); usually very thin and frequently absent.

A_0 Horizon.—Slightly to highly decomposed organic matter (F and H layers); Usually the well decomposed (H) layer is the chief constituent of the A_0 horizon. The H layer consists of mixed brownish-black mat of organic matter (1" to 3" thick—may be absent if recently burned).

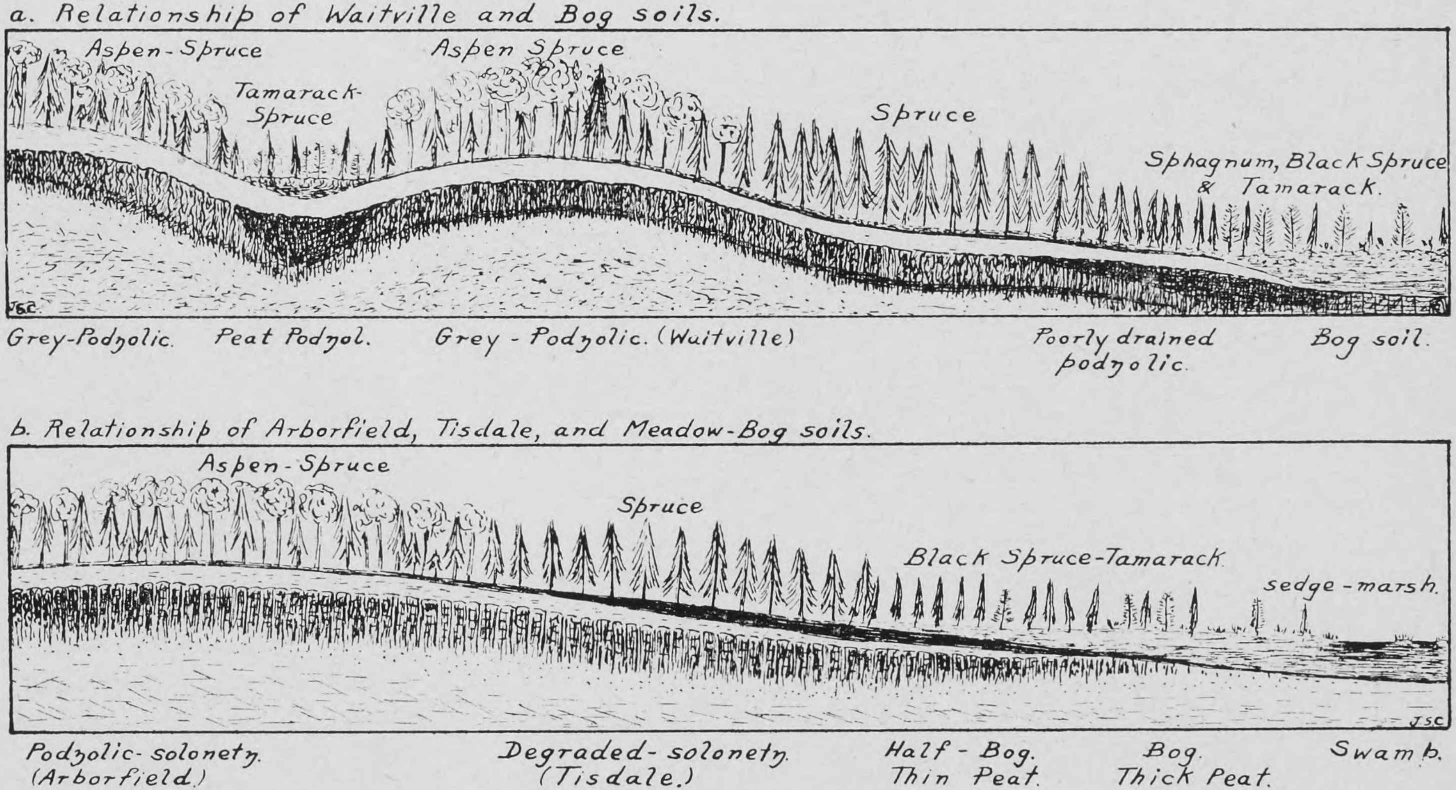


FIGURE 7
Profile Relationships in the Grey Soil Zone.

A_1 Horizon.—Brown to dark brown; mixed organic and mineral matter; granular to weak platy structure; sometimes absent except as thin, dark staining (0" to 1" thick).

A_2 Horizon.—Light (ashy) grey to light brownish-grey; platy structure, breaking to powdery, loose condition when dry (5" to 10" thick).

B_1 Horizon.—Dark ("coffee") brown to brown at top, fading to brown or grey-brown below; massive structure when wet; hard and compact when dry with a nutty to angular fragmental structure; heavier textured than A_2. Sometimes thick platy-cloddy A-B horizon occurs between the A_2 and B_1 (6" to 10" thick).

B_2 Horizon.—Yellow-brown to grey-brown; massive structure breaking to nutty aggregates; heavy texture; decomposing glacial stones often present (4" to 8" thick).

C_1 Horizon.—Medium grey, often with faint yellowish tinge; massive to faintly laminated appearance, crushing easily to granular aggregates; moderate to high lime carbonate content; boulder clay containing glacial stones and decomposing stones (12" to 14" thick).

C_2 Horizon.—Greyish boulder clay with rusty, bluish-grey, and whitish streaks and spots; moderate lime content.

A thinner Upland Podzolic member of the Waitville Association may also be encountered. This member differs from the profile described above in having a thinner A_2 horizon (4" to 6" thick) and a calcareous (limy) B(ca) horizon immediately below the B_1 horizon. This profile is more common in Waitville soils located south of Township 48. It may also occur in the present area in Waitville soils on rolling topography, occupying a position between the Shallow Knoll and the Thick Upland Podzolic members.

Waitville Shallow Knoll Profile:

A_0 Horizon.—Usually very thin.

A_1 Horizon.—Very thin or absent.

A_2 Horizon.—Grey to brownish-grey; platy (2" to 4" thick).

B_1 Horizon.—Reddish-brown to brown; coarse granular (4" to 6" thick).

B-C Horizon.—Grey, massive structure; moderately high lime content (6" or more thick).

C Horizon.—Greyish boulder clay, moderate lime content.

Waitville Poorly Drained Profile:

A_0 Horizon.—Thin, partially decomposed leaves (F layer) and dark brown granular highly decomposed material (H layer) (1" to 4" thick).

A_1 Horizon.—Dark grey; platy structure (1" to 3" thick).

A_2 Horizon.—Light brownish-grey to light grey with rusty streaks; platy structure, crushing to powdery-very fine granular aggregates (4" to 8" thick).

B_1 Horizon.—Dark brownish-grey, mottled with rusty-yellowish and blue-grey spots and streaks; massive structure, breaking to hard coarse granular and nutty aggregates (6" to 12" thick).

B_2 Horizon.—Similar to B_1 but with more mottled colouring; may contain lime near bottom.

C Horizon.—Mottled, poorly drained boulder clay, containing lime carbonate.

Waitville soils are mapped as a complex, or mixed soil area, with Loon River, Garrick, Whitewood, Pelly, Paddockwood, Bodmin, Sylvania, and Meadow-Bog soils respectively. Waitville soils are easily distinguished from the above associations, with the exception of the Loon River and Garrick. The Loon River Upland Podzolic member is very similar to that of the Waitville. In general, the Loon River has thicker A_2 and B horizons, and the parent material is less calcareous. Garrick soils are developed on lake modified till; they usually have pale brown A_2 horizons and granular B horizons.

PLATE 25

Prairie or upland hay is still found on the rolling grasslands north of the Big Gully.

Sedges and meadow grasses are cut for hay on lowland or meadow areas.

Agriculture.—Many agricultural problems are associated with the Waitville soils. This is true of even the better types which are producing fair to good crops. Most of the problems listed below are associated with the other grey podzolic soils of Saskatchewan. These problems are also discussed in the section on Soils and Agriculture.

The Waitville soils are lower in potential fertility than the degraded black and black soils of similar texture and geological origin. The grey soils are lower in organic matter, nitrogen, phosphorus, and sulphur. It is also difficult to keep the Waitville soils in good tilth, since they are soft and loose structured when moist, but tend to "bake" or form a hard compact surface crust when dry. In addition, these soils may be associated with several or all of the following undesirable factors: heavy cost of clearing trees and stones; short growing season with danger of frost damage to crops; considerable proportion of rough topography or of non-arable muskeg and marsh areas. Finally the wheat crops are of distinctly lower quality (low protein content) as compared with those grown on the grassland soils.

On the other hand, the Waitville soils occur in a region of favourable moisture conditions and severe droughts are rarely experienced. Furthermore, it has been shown that the low initial productivity of these soils can be greatly increased by the use of commercial fertilizers and manure, and the adoption of suitable rotations which include leguminous crops.

The better Waitville soils consist of clay loam and heavy loam types on smooth undulating topography. Such areas have few stones and little waste land. The Waitville soils are used largely for grain production with a considerable acreage of wheat, although barley and oats are more commonly grown where frost is a serious hazard. In certain districts Waitville and other grey soils are used for the production of alfalfa seed.

Waitville loam and light loam soils with thick, strongly leached A horizons are less suitable for the production of grains, while those of rough topography or excessive amounts of stones are poor to non-arable types. The loam is rated at 42 and light loam at 38. Waitville clay loam is rated at 50.

It should be pointed out that many of the Waitville soils represent areas of comparatively recent settlement. Hence, agricultural development is still in the pioneering stage. The acreage under cultivation is small on most farms and the clearing and breaking of new land is costly. Under such conditions it is difficult for the average settler to adopt suitable rotations and to secure manure and fertilizers. It is certain, however, that a satisfactory and permanent type of agriculture can only be established through careful management of these soils. This will involve the improvement of both fertility and physical condition of the soil. Information on the problems and management of the Waitville and other grey soil associations is obtainable from the sources indicated below*.

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*(1) Department of Soils, University of Saskatchewan, Saskatoon.
(2) The Dominion Experimental Stations, at Scott and Melfort, which direct the work of the northern sub-stations.
(3) "Wooded Soils and Their Management." J. D. Newton. Bull. 21 (revised) 1938. Extension Department, University of Alberta, Edmonton, Alberta.

LOON RIVER ASSOCIATION

Description.—The Loon River Association consists of grey podzolic loamy soils on morainic boulder clay that has a relatively low content of lime. Most of the lime carbonate exists in the parent material in streaks and spots, whereas in most boulder clays so far encountered the lime is more uniformly distributed and is present in larger quantities. Compared with Waitville soils, the Loon River profiles are deeper and the lime is encountered at greater depths.

The Loon River soils are, next to the Waitville, the most extensive podzolic soils of the present surveyed area. They occupy large areas of the Beaver River Plain and also occur on the Coteau Upland between St. Walburg and Loon Lake. About 400,000 acres were mapped in this association.

The soil landscape of the Loon River Association is essentially similar to that of the Waitville. There is the cover of mixedwood forest vegetation, the "wavy" surface of knoll, slope and depression, and numerous glacial stones and boulders. By observation it would appear that the Loon River soils are more stony than the Waitville. A feature of some undulating areas of Loon River soils is the presence of isolated ridges or hillocks of drumlin-like form. The cultivated Loon River soils are light grey in colour. There is a great deal of uncultivated land, and agricultural development has been slow. The remoteness of many Loon River soil areas has resulted in sparse settlement, with very few roads and small scattered areas of cultivated land.

The topography of the Loon River Association ranges from very gently undulating to strongly rolling and hilly. The morainic wave-like form already referred to is characteristic. Undulating ground moraine areas may be broken by the isolated drumlin-like ridges and small hills also referred to above. About 190,000 acres were mapped as undulating, and 130,000 acres as mixed undulating and rolling topography, which may also include roughly undulating. About 66,000 acres were mapped as strongly rolling to hilly—two and one-half times the acreage of this topography mapped in the Waitville Association. Most of the better developed settled areas consist of undulating and mixed undulating-gently rolling topography.

Surface drainage of Loon River soils is satisfactory in most places. Excessive surface drainage is associated with the steep slopes of rolling and hilly areas. Poor surface drainage is associated with the flat land surrounding muskeg and meadow areas. These depressional areas are generally undrained or merely overflow when the water table is high. Internal or soil profile drainage is satisfactory in heavier textured Loon River soils on well drained undulating positions. The deeply leached lighter textured soils are somewhat excessively drained in the leached portion of the profile. Impeded profile drainage occurs in heavier textured Loon River soils bordering wet depressions.

Glacial stones and boulders are present in all Loon River soils. In many areas large stones (boulders) predominate, limestone boulders are rare. One-quarter of these soils are mapped as very stony to excessively stony land (S_3 to S_4). Gravel sized stones are infrequent,

except where Loon River soils occur as a complex with soils developed on glacial outwash (Bodmin Association).

Loon River soils are mapped as loam, light loam (gritty loam), and clay loam. The loam is most common—occupying over 80 per cent. of the total area; the light loam occupies most of the remainder, there being only 11,000 acres mapped as clay loam.

The dominant member profile of the Loon River Association is the Upland Podzolic. Poorly Drained and Shallow Knoll members also occur, and in at least one area complex Podzolic-Solonetzic profiles were encountered.

Generalized descriptions of the more important member profiles are given below:

Loon River Upland Podzolic Profile:

A_{00} Horizon.—Twigs, leaves, needles, moss (leaf litter); usually thin, and absent where forest has been burned (0″ to 3″ thick).

A_0 Horizon.—Slightly to highly decomposed organic matter (F and H layers); usually dark coloured—very dark brown to nearly black (1″ to 2½″ thick, may be absent if recently burned).

A_1 Horizon.—Brownish to light brown; mineral soil with some organic material from above; platy structure; frequently absent and usually thin (0″ to 1″ or 2″ thick).

A_2 Horizon.—Light brownish-grey or very pale brown above to light grey (ashy) below; platy structure, hard and brittle when dry and crushing to powdery or loose structureless condition; this horizon has a harsh, gritty "feel" which gives the impression that the soil is sandy textured. Analyses indicate that it is a loam with a high content of silt (6″ to 15″ thick, average 8″ to 10″).

A-B Horizon.—Light grey to brownish-grey; thick platy structure and heavier textured than A_2. Appears to represent leaching of former B horizon; not always present (0″ to 3″ thick).

B_1 Horizon.—Dark brown above with very dark brown staining on the outside of larger soil aggregates; greyish brown below; massive structure, hard and very compact, breaking to hard nutty and fragmental aggregates; clay texture (7″ to 18″ thick).

B_2 Horizon.—Yellow-brown to greyish-brown; massive structure, hard and compact, breaking to large angular fragments, these frequently show a grey coating; when crushed to granular condition the material has a yellowish-brown colour; many decomposing glacial stones with considerable mica exposed (8″ to 18″ or more thick).

C_1 Horizon.—Light to medium grey boulder clay; slight to moderate lime carbonate content, occurring in streaks and spots; massive to faintly laminated structure.

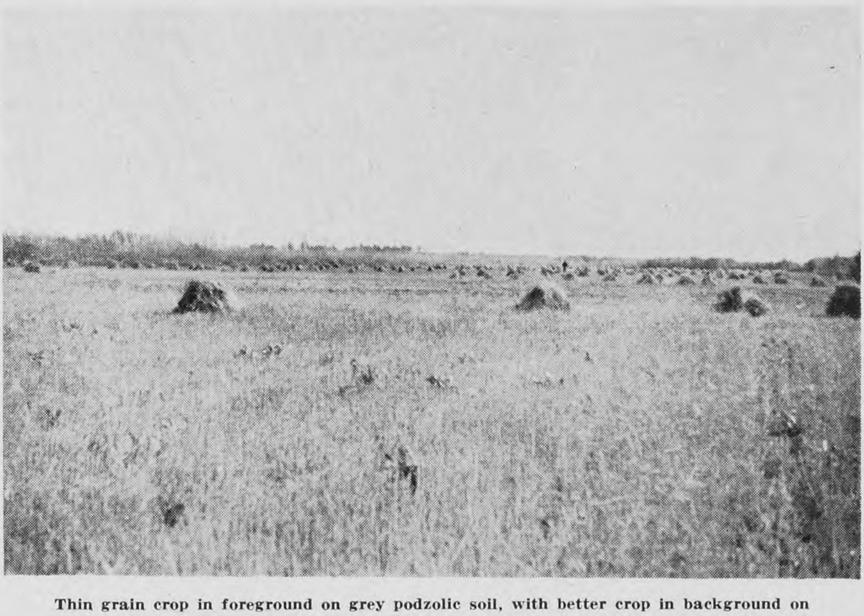
C_2 Horizon.—Medium to dark grey boulder clay crushing to faint yellowish-brown colour; massive structure, breaking to small jointed columnar-like aggregates, and these to irregular nutty and fragmental aggregates; lime carbonate is present in streaks and spots; this horizon is very compact, and hard to penetrate when dry.

Poorly Drained members of the Loon River Association occur on flat land or meadow-bog areas. The profiles are essentially similar to the Waitville Poorly Drained members, differing chiefly in containing less lime and in having thicker horizons.

The Shallow Knoll member of the Loon River Association has an A_2 horizon of 4″ to 6″ thick, and rich (coffee) brown B_1 and a yellow-brown B_2. These horizons are thinner than in the upland podzolic and a somewhat higher content of lime occurs in a B_3 or C_1 horizon immediately below the B_2.

PLATE 26

Heavy oat crop on degraded black soil, showing lodging after a rain storm.



Thin grain crop in foreground on grey podzolic soil, with better crop in background on degraded black soil.

The complex Podzolic-Solonetzic profile has not been studied in detail. It was not encountered very often, although it may turn out to be more common than the preliminary survey indicates. This profile is recognized by its thick A_2 and A_3 horizons, and the dark, waxy, compact B_1 horizon. The latter may have round tops, coated with white powdery (siliceous) material. Another characteristic is the undulating or "wavy" form of the B horizon which occurs at varying depths below the surface, as mentioned in the section dealing with the Horsehead Association.

Loon River soils are mapped as complexes, or mixed soil areas, with Horsehead, Bodmin, Waitville, and Meadow-Bog soils respectively. There is also a complex of Loon River, Waitville and Bodmin soils. Horsehead soils are distinguished from Loon River types by the darker and thicker A horizons, the Loon River representing the podzolized equivalent of the degraded Horsehead soils. Loon River and Waitville soils are less easily distinguished. They occur where the glacial till carries more lime than the main belt of Loon River soils and the mapping of both associations is based upon difference in depths to, and amount of, lime in the profile. Bodmin soils are distinguished from the Loon River Association by their coarse sandy to gravelly textures.

Agriculture.—The Loon River soils present the same general problems of agricultural development that were discussed under the Waitville Association and are rated about the same. Loon River clay loam is rated at 52, the loam at 43 and the light loam at 37. The Loon River soils are associated with large areas of stony land and with remote areas that are far from railway facilities. Hence, while the best Loon River soils are equal or slightly superior to the average Waitville type, many Loon River soils are undeveloped and have low agricultural ratings. The light loam types of both associations are inferior soils.

Loon River soils are used for the production of wheat, barley, and to some extent alfalfa seed. The wheat is likely to be of low milling quality and is also subject to frost damage. The long distance to railway points from many Loon River soil areas is a further handicap to the production of cash grain crops. The feeding of barley to livestock is a common practice. Some of the unbroken land has a fairly high carrying capacity as grazing land for cattle. In addition to native feed in meadow areas, burned-over lands develop a fair grass cover.

BODMIN ASSOCIATION

Description.—The Bodmin Association consists of grey podzolic coarse sandy and gravelly to gritty loams developed on glacio-fluvial deposits. These deposits consist of coarse-textured outwash, stream-eroded boulder clay, and kames, resulting from the rapid melting of glacial ice and the washing of glacial deposits by large volumes of water. As a result the fine textured material was largely removed, leaving behind the coarse material. The Bodmin soils represent the strongly leached or podzolized equivalent of the Glenbush soils.

The Bodmin Association is scattered throughout most of the present surveyed area. The larger areas of Bodmin soils occur on

the Prince Albert Park Upland; along the eastern margin of the Coteau and its western extension; and on the Beaver River Plain. About 310,000 acres were mapped in this association.

The Bodmin Association represents a newly established group of soils. In former surveys the present Bodmin soils were covered under Waitville sandy loams and the coarser types of Sylvania sandy loams.

The soil landscape of the Bodmin Association is similar to that of the Glenbush Association. The most marked difference is the lighter grey colour of the cultivated Bodmin soils, corresponding to their more strongly leached condition. Both associations are characterized by the coarse sandy to gravelly nature of the surface soils and exposed road cuts. Small rounded stones (cobble) are common in many areas. The tree cover is not as well developed as that of better textured soils. Agricultural development is poor, and considerable unbroken and unsettled land occurs.

The topography of Bodmin soil areas ranges from nearly level outwash plains to rough, rolling kame deposits. About two-thirds of the Bodmin soils are mapped in nearly level to undulating topography and close to one-quarter of the total acreage as rolling to strongly rolling.

Surface drainage is adequate in Bodmin soil areas. Internal or soil profile drainage is excessive in most Bodmin soils, which are among the least drought resistant soils of the Grey Soil Zone.

Conditions of stoniness are variable, many of the sandy loams being stone-free, while the gritty and gravelly loams vary from slightly to excessively stony (S_1 to S_4). Although large stones and some boulders may occur, many of the stones are small cobble size (three to six inches in diameter). These are frequently so numerous that their complete removal is impracticable.

Gravelly subsoils and spots of surface gravel are common in Bodmin soil areas.

Bodmin soils are mapped as gravelly loam, sandy loam, mixed gravelly to sandy loam, loamy sand, and light loam. The latter represents a gritty loam as described under the Whitesand Association.

The Bodmin Association consists of Upland Podzolic, Podzolized Sand, and shallow, weakly developed member profiles. The Upland Podzolic occurs in gravelly and gritty light loam areas; the Podzolized Sand member is associated with sandy loam and loamy sand profiles.

Generalized descriptions of the more important Bodmin profiles are given below:

Bodmin Upland Podzolic Profile, gravelly light loam texture:

A_{0-1} Horizon.—Grey to dark grey; loose mineral soil with some organic matter and ash-residue after burning (about 1" thick).

A_2 Horizon.—Light grey (ashy) with faint brown tinge when moist; thin platy structure, falling easily to powdery and loose structureless condition; some small stones and gravel present (6" to 10" thick).

B_1 Horizon.—Mottled brown, rusty-yellow-brown and grey; massive structure; variable texture, but frequently sandy clay loam to sandy clay (10" to 14" thick).

C Horizon.—Mottled colours as above, but more yellowish; eroded boulder clay of stony, gravelly-sandy clay loam texture; usually slightly calcareous.

Bodmin Upland Podzolic Profile, sandy loam texture:

A_0 Horizon.—Usually thin and frequently absent due to forest fires; mixed raw and partially decomposed leaf litter and organic matter (0″ to 1″ thick).

A_1 Horizon.—Mixed dark grey and light grey; platy to loose structureless fine sandy loam (½″ to 1″ thick).

A_2 Horizon.—Very light grey with faint brown tinge, to very pale brown when moist; weakly developed thick platy structure, breaking to loose structureless (single grain) condition (10″ to 14″ thick).

B_1 Horizon.—Dark brown; massive, breaking to rough irregular cloddy aggregates; sandy clay texture (6″ to 8″ thick).

B_2 Horizon.—Yellow-brown to brown sandy clay loam; massive, breaking to hard flat, clod-like aggregates when dry (10″ to 12″ thick).

C Horizon.—Brownish-yellow sandy deposit; stone-free; no lime carbonate.

Bodmin Podzolized Loamy Sand Profile:

A_0 Horizon.—Thin to absent.

A_1 Horizon.—Usually absent; when present may represent only dark staining of mineral particles (0″ to 1″ thick).

A_2 Horizon.—Light brownish-grey; weak platy structure, falling easily to loose (structureless) condition; medium to coarse loamy sand and sand (8″ to 16″ thick).

B_1 Horizon.—Brown to faint reddish-brown; weak massive structure, falling to soft weak cloddy aggregates and easily crushed to loose particles; loamy sand to light sandy loam (10″ to 16″ thick).

B_2 Horizon.—Yellow-brown; weak massive to structureless; difficult to separate from C horizon (0″ to 10″ thick).

C Horizon.—Yellow-brown to yellowish loamy sand and sand. Lime-free.

The profile variations caused by the presence of gravelly-sandy-cobbly lenses occurring at varying depths within the profile have been discussed under the Whitesand Association. This discussion applies also to the Bodmin Association.

Bodmin soils are mapped as a complex or mixed soil area with Glenbush, Waitville, Loon River, Horsehead, Sylvania, Pine, Meadow-Bog, and Smeaton soils respectively. In most instances, the combination of thick, leached (podzolized) A horizons and coarse sandy to gravelly textures are the main features by which the Bodmin Association is identified.

Agriculture.—The Bodmin soils are among the poorest agricultural soils in the province. They are low in drought resistance and low in natural fertility. In many areas rough topography or frequent gravel subsoils and cobble deposits are other adverse features. Bodmin soils are more strongly leached than the Glenbush soils, and on that account are given lower ratings. Bodmin gritty loam (light loam) and gravelly loam soils are rated at 29, and sandy loam at 18. By the time deductions are made for topography, stoniness, and other factors many of the Bodmin soils are rated so low that they are regarded as non-arable. Most Bodmin soil areas are very poorly developed.

Bodmin soils require additions of organic matter, nitrogen, phosphorus and possibly sulphur, in order to supplement the low supply of these materials in the natural soil. The problems associated with the coarse textures, such as low water holding capacity and poor

drought resistance cannot be changed to any great extent. It is difficult, therefore, to see how any great improvement can be made in the productivity of these soils under the prevailing system of grain farming. Under this system little or no return of depleted elements or organic matter is made. Alfalfa seed production is carried on in some Bodmin soil areas, and this is a better crop than wheat for these soils.

PINE ASSOCIATION

Description.—The Pine Association consists of grey podzolic fine sands and loamy sands on alluvial and aeolian deposits. It is considered that the sands were deposited by water, but that in some areas they were later re-worked by wind to form dunes and low smooth ridges. In the eastern section the original source of sandy material may be the underlying sandstone formations of Lower Cretaceous Age.

The Pine Association occurs throughout the forested section of the present surveyed area. The more extensive areas of these soils occur on the Saskatchewan Lowland, particularly near Prince Albert, north of Whitefox, and north-east of Nipawin; on the Shellbrook Plain, between Shellbrook and Canwood; and on the Beaver River Plain north and north-east of Meadow Lake. About 230,000 acres were mapped in the Pine Association. South of the present surveyed area about 60,000 acres of Pine soils were mapped.

The soil landscape of the Pine Association is characterized by the loose sandy surface of grey to brownish-grey colour, the predominance of jack pine vegetation, the absence of stones, and level to dune-like topography. Pine soils of dune topography occurring as a complex with other associations were mapped as strongly rolling. Lower areas may carry a vegetative cover of jack pine, poplar and spruce, and the wet depressions consist of tamarack and black spruce bogs. In most areas little or no cultivation has taken place on Pine soils, and what farms do exist are usually poorly developed. Where better agricultural development has occurred it will generally be found that the Pine soils are mixed with better soils of another association, or that the Pine soils are shallow and are underlain by heavier textured D horizons.

About 65 per cent. of the Pine Association occurs on level to undulating topography, 22 per cent. on very gently rolling, and 13 per cent. on rolling to strongly rolling. The very gently rolling to rolling topography will include the sand dunes formed by the wind.

Surface drainage is absent in most Pine soils, since they absorb all water that falls on them. Hence, streams are rarely encountered, unless they have cut into heavier textured deposits underlying the sands. Water may move away underground, along the contact of the sand and clay, or in other places may form a shallow water table. Internal, or soil profile, drainage is excessive and Pine soils have a very low water holding capacity. Where water occurs at shallow depths it is certain that heavier textured subsoils are present, thus enabling the sands to act as a reservoir. Pine soils are typically stone-free. Gravel and boulders may be encountered where the Pine profiles are shallow.

Most of the Pine Association is mapped as sand, which is chiefly of fine sand texture. Very fine sand to loamy sand textures also occur, but were not separated in the present survey.

In texture and origin of parent material the Pine soils are similar to Dune Sands and Undifferentiated Sands. The latter have little or no profile development, whereas the Pine Association consists of podzolized profiles.

The member profiles of the Pine Association consist chiefly of the Podzolized Sand, together with some Upland Podzolic profiles.

Generalized descriptions of the important Pine profiles are given below:

Pine Podzolized Sand Profile:

A_{00} Horizon.—Thin layer of undecomposed needles and cones (leaf litter).

A_0-A_1 Horizon.—Brown decomposed organic matter mixed with grey silica particles (sand grains) (½″ to 1″ thick).

A_2 Horizon.—Light grey (ashy) to faint brownish-grey; loose, structureless fine sand (8″ to 12″ or more thick).

B_1 Horizon.—Brown; loose structureless to weak massive structure; fine to very fine sand (12″ to 24″ thick).

B_2 Horizon.—Yellow-brown fine to very fine sand; loose and structureless; this horizon may be difficult to distinguish from the C horizon (12″ or more thick).

C Horizon.—Light yellow-brown fine sand; loose and structureless; usually lime-free.

Pine Upland Podzolic Profile:

A_{00} and A_0-A_1 Horizons.—Similar to those described above.

A_2 Horizon.—Light (ashy) grey; fine and very fine sand; loose and structureless (8″ to 15″ thick).

B_1 Horizon.—Brown, streaked with white silica particles; fine sandy loam; nutty to irregular cloddy structure, moderately hard when dry, and crushing to loose powdery condition (18″ to 24″ thick).

B_2 Horizon.—Greyish-brown fine sandy to very fine sandy loam; massive structure, breaking easily to loose structureless condition (18″ to 24″ thick).

C Horizon.—Yellowish-brown fine to very fine sand; loose structureless condition.

Profiles with loamy sand textures have thicker A_1 horizons and thinner A_2 horizons than the above. The A_2 horizon is brownish-grey in colour.

A somewhat poorly drained profile occurs on low flat topography. It is characterized by a mixed poplar and spruce vegetation. The grey A horizons are marked with rusty streaks; the B and C horizons are greyish-yellow with rusty streaks and spots.

An important variation of the Pine soils occurs where clay subsoils (D horizons) underlie the Pine sandy deposit. Where these heavier textured deposits can be observed in road cuts, they are near enough to the surface to directly affect the agricultural value of the Pine soils. The clay prevents the loss of soil water by percolation, and thus makes the sandy soil more drought resistant. In addition, deep rooted crops may secure nutrient elements from the clay. In the present area, clay D horizons were observed in some areas at depths ranging from 3 to 6 feet. On a more detailed survey such areas could be separated on the soil map.

The Pine Association has been mapped as a complex or mixed soil area with a number of sandy textured associations and Meadow-Bog and Muskeg soils respectively. The sandy soils include Bodmin, Glenbush, Shellbrook, Carrot River and Dune Sands.

Agriculture.—Most of the Pine soils are uncultivated and are regarded as non-arable soils. They are low in natural fertility, have a very low water holding capacity and are highly susceptible to wind erosion. Attempts to settle and cultivate these soils have generally proven unsuccessful.

The best use of most of these soils is in permanent and controlled forest land. They may then serve as game preserves, public domain and also furnish a regular crop of wood for fuel and other purposes. The Nisbet Forest Reserve is an example of the proper utilization and management of jack pine forest on the Pine Soil Association.

Where arable agriculture is practiced on Pine soils, best results are obtained on the very fine sand and loamy sands, by growing legume crops such as alfalfa or clover. The Pine soils underlain by clay subsoils are the most desirable types for agricultural development. The low native fertility and the danger of wind erosion are such serious handicaps, however, that cultivation should only be permitted under the best possible soil management. Control of erosion should be safeguarded by regulations, if necessary, so that mismanagement of such soils may be prevented.

SYLVANIA ASSOCIATION

Description.—The Sylvania Association consists of grey podzolic fine textured sandy loam soils developed on sandy alluvial-lacustrine deposits. These soils are scattered throughout the present surveyed area, often in combination with other light textured soils. About 77,000 acres were mapped in this association. The Sylvania soils also occur south of the present area and 170,000 acres were mapped in the No. 12 survey. However, at that time the Bodmin Association had not been established, and some coarser textured sandy loams were included in the Sylvania Association. Similarly, soils now mapped as the La Corne Association were formerly included in the Sylvania Association.

The soil landscape of the Sylvania Association is characterized by smooth undulating topography and a wooded cover of dense but relatively short-growing aspen, with occasional pine and spruce. Meadow and Bog (Peat) soils occupy undrained depressions. Cultivated fields present a light grey to light brownish-grey colour. The soils are further characterized by their uniform fine textured sandy nature, stones and gravel being typically absent. Agricultural development is fair to poor and considerable uncultivated land occurs in most areas of Sylvania soils.

Over 60,000 acres, representing about 80 per cent. of the Sylvania soils occur on nearly level to undulating topography, and only about 9,000 acres were mapped as strongly rolling. The rolling areas are confined to the Meadow Lake district and the strongly rolling topography to the escarpment of the Coteau, west of Shellbrook.

Surface drainage is satisfactory in most Sylvania soil areas except for the local undrained depressions which, however, are not frequent in typical Sylvania areas. Internal or soil profile drainage is satisfactory in the heavier textured profiles, but is excessive in the lighter textures and in profiles with non-compacted B horizons.

Stones and gravel are rarely encountered in Sylvania soils, which are typically developed on uniform fine textured sandy deposits.

The textural classes of the Sylvania Association include fine sandy loam, very fine sandy loam, and sandy light loam. The fine sandy loam represents nearly 60 per cent. of the total acreage, the very fine sandy loam about 28 per cent. and the light loam is inextensive.

The Sylvania soils represent the grey podzolized equivalent of the degraded Shellbrook soils. The parent material deposits of the two associations are of similar geological origin, and they are separated on differences in degree of podzolic leaching. As already indicated, coarser textured grey soils formerly classified as Sylvania are now placed in the Bodmin Association. Hence, Sylvania coarse sandy loam shown on the map of No. 12 Report should now be regarded as Bodmin sandy loam.

Member profiles of the Sylvania Association consist chiefly of the Podzolized Sand and Upland Podzolic soils.

Generalized descriptions of important Sylvania profiles are given below:

Sylvania Podzolized Sand Profile:

A_{00} Horizon.—Thin layer of twigs and leaves (leaf litter).

A_0 Horizon.—Partially decomposed organic matter, frequently absent due to forest fires (0" to 2" thick).

A_1 Horizon.—Dark grey sandy soil, weak platy to structureless (0" to 1" thick). Where A_0 has been disturbed or destroyed a mixed A_0-A_1 horizon results which may be 2" to 3" thick.

A_2 Horizon.—Light (ashy) grey to grey with faint brown tinge; light fine sandy loam texture; weak platy structure to loose structureless condition (8" to 18" thick).

B_1 Horizon.—Brown to yellow-brown fine sandy loam; faint soft cloddy structure to loose structureless condition (0" to 16" thick).

B_2 Horizon.—Yellowish-brown; loose structureless condition; may not be easily distinguished from C horizon (8" or more thick).

C Horizon.—Yellowish-brown to light greyish-brown sand and loamy sand; slightly calcareous to lime-free.

Sylvania Upland Podzolic Profile:

A_0 Horizon.—As above.

A_1 Horizon.—Dark grey to grey sandy soil; weak platy structure (1" to 2" thick).

A_2 Horizon.—Light grey with brown tinge; platy to structureless (6" to 12" thick).

B_1 Horizon.—Reddish-brown to brown; cloddy to nutty structure, moderately hard to quite hard and compact (8" to 12" thick).

C Horizon.—Yellow-brown to light greyish-brown loamy sand to sandy loam; slightly calcareous to lime-free.

The Sylvania Association has been mapped as a complex or a mixed soil area with Shellbrook, Dorintosh, Glenbush, La Corne, Pine, Waitville, and Meadow-Bog soils respectively.

Agriculture.—In general Sylvania soils are not well developed agriculturally. The soils are highly leached and hence are not well supplied with nitrogen and organic matter. They are also low in drought resistance, particularly the fine sandy loam type.

The loose sandy structure of the cultivated soils makes them susceptible to wind erosion. All these adverse factors give Sylvania soils a low rating for grain farming. Sylvania sandy light loam is rated at 47, the very fine sandy loam at 42, and the fine sandy loam at 33.

These soils should be more valuable when more legume and other forage crops are grown and less wheat is produced. The addition of organic matter and the use of fertilizers carrying nitrogen, phosphorus and sulphur are likely to be essential to the continuous use of these soils under arable agriculture.

ARBORFIELD ASSOCIATION

Description.—The Arborfield Association consists chiefly of complex podzolic-solonetzic soils developed on glacial-lacustrine clay deposits. In the present surveyed area these soils are confined to the north-easterly section of the Saskatchewan Lowland, where they occupy 25,000 acres. The main belt of Arborfield soils lies south of Township 48, where over 300,000 acres were mapped in former surveys.

The soil landscape of the Arborfield Association of the present surveyed area is characterized by nearly level to flat-depressional topography. The vegetation ranges from mixedwood forest to swamp —the latter including black spruce and peat. Wet, undrained areas are common, and drainage is required before such lands can be cultivated. Many of the Arborfield soil areas were being drained and cleared, or had been settled for only a relatively short time when the present survey was carried out. Hence, cultivated areas were marked by patches of peaty soil inter-mixed with dark grey to grey mineral soils. Stones and gravel are absent.

The whole of the Arborfield Association was mapped in flat to very gently sloping topography, and most of the land appears to be flat with only a very slight local relief.

Stones and gravel are absent except where the underlying boulder clay is penetrated by drainage ditches or road cuts. Stones are rarely encountered in ordinary tillage operations.

The Arborfield soils are mapped as clay and heavy clay. The clay texture represents about 80 per cent. of the total acreage.

In the present survey most of the Arborfield soils consist of Podzolic-Solonetzic member profiles, in many instances representing more poorly drained conditions than are associated with the main belt of Arborfield soils.

Generalized descriptions of important Arborfield profiles are given below:

Arborfield Podzolic-Solonetzic Profile:

A_0 Horizon.—Partially decomposed organic matter; frequently absent due to forest fires or burning prior to settlement (0″ to 4″ thick).

A_1 **Horizon.**—Grey to dark grey; platy-granular structure; usually thin and may be absent (0" to 1" thick). This horizon may be mixed with remnants of A_0 and plant ash where fires have modified original vegetation.

A_2 **Horizon.**—Light grey (ashy) to brownish-grey; thick platy structure, breaking to coarse granular (3" to 8" thick). In some places a nutty structured A-B horizon may be distinguished at the bottom of the A_2, and grading into the B_1.

B_1 **Horizon.**—Very dark brown to greyish-brown heavy clay; large blocky structure, with faint columnar cleavage and faintly developed round-top structure at the top; breaking to very hard nutty and angular fragmental aggregates; this horizon shows characteristic "wave-like" or undulating form in road cuts (8" to 14" thick).

B_2 **Horizon.**—Greyish-brown heavy clay; may show yellowish, rusty and greyish streaks where drainage is poor; massive structure breaking to hard nutty aggregates (6" to 12" thick).

C **Horizon.**—Banded dark grey heavy clay and greyish-brown clay or silty clay; occasional whitish streaks of lime carbonate; more rusty, yellow, bluish-grey colours in poorly drained soils.

The Poorly Drained Podzolic-Solonetzic profiles are characterized by a surface layer of undecomposed peat and needles, underlain by a partially decomposed peat. The thickness of the peat layers varies from 8" to 20" or more. A_1 horizon—very dark grey (1" to 3" thick). A_2 horizon—grey with rusty and yellow streaks. B_1 horizon—very dark grey with rusty streaks. B_2-C horizon—mottled colours, wet and poorly drained. Profiles in slight depressions consist of a thin grey A_2 horizon over a round-topped, heavy compact columnar B_1. This profile is somewhat like the eroded solodized-solonetz or "burn-out" soils of the Brown and Dark Brown Soil Zones.

The Arborfield Association is mapped as a complex or mixed soil area with the Tisdale Association. The latter is distinguished by a thicker A_1 horizon, a darker coloured A_2 horizon, and by the absence of well developed solonetzic features.

Agriculture.—The agricultural development of the Arborfield soils of the present area has proceeded slowly. Heavy clearing, thick peat in some places and the necessity of establishing drainage have handicapped settlement. The Arborfield soils are rated slightly below Tisdale soils of similar texture. Arborfield heavy clay is rated at 60 and the clay at 63.

Arborfield soils are used principally for wheat production, with a fair amount of coarse grains and some alfalfa. The development of satisfactory surface structure, or state of good tilth, is a problem. Where the heavy solonetzic B horizon approaches the surface thin and patchy crops have been observed. For such soils in particular it is likely that applications of manure and phosphatic fertilizers would improve crop yields. A greater use of legumes and other forage crops may also be desirable. On the Arborfield soils of the present surveyed area, erosion is not a serious problem.

GARRICK ASSOCIATION

Description.—The Garrick Association consists of grey podzolic and brownish-grey podzolic soils developed on lake-modified boulder clay. These soils are the podzolized equivalent of the degraded black Kelsey soils. Hence, the definition of lake-modified boulder clay, given in the section on the Kelsey Association, is applicable also to the Garrick Association.

PLATE 27

Unfertilized strip in barley field fertilized with 11-48-0, ammonium phosphate. Fertilized crop is heavier and earlier.

Oat crop unfertilized on left. 11-48-0 at 40 pounds per acre on right.

The Garrick soils occur on the Saskatchewan Lowland, chiefly between Choiceland and Whitefox and north to the Torch River. About 55,000 acres were mapped in this association.

The soil landscape of the Garrick Association is characterized by smooth, nearly level to gently undulating topography, a heavy mixedwood forest cover and the presence of glacial stones and boulders. The surface soils, as observed in cultivated fields and in road cuts, are lighter coloured than the Kelsey soils, but in comparison with the Waitville soil colours the Garrick soils have a faint to distinct brown tinge. Agricultural development is fair to poor, much of the area having been settled only a short time.

The Garrick soils occur principally on very gently undulating topography, with some areas of gently undulating land. Only 4,000 acres were mapped as strongly undulating.

Surface drainage is satisfactory in most places, except in local Meadow-Bog areas. Internal or soil profile drainage is good to moderate. The latter condition is associated with the Podzolic-Solonetzic profiles which have a compact impervious B horizon, and also with Garrick soils bordering undrained flat-depressional areas.

Garrick soils are in general slightly to moderately stony (S_1 to S_2). A few areas are stone-free or contain only occasional pebbles. A few local areas of very stony soils (S_3) also occur.

Garrick soils are mapped in clay loam, loam and light loam textures. The clay loam and loam each occupy about 26,000 acres, while the light loam is inextensive and represents less than 2,000 acres. Some silty clay loam is included with the clay loam.

Member profiles of the Garrick Association include Grey Podzolic, Brownish-Grey Podzolic and complex Podzolic-Solonetzic profiles. Local areas of Poorly Drained and Shallow Knoll profiles also occur.

Generalized descriptions of the more important Garrick profiles are given below:

Garrick Grey Podzolic Profile:

A_0 Horizon.—Partially decomposed organic matter; frequently disturbed or burned (0″ to 2″ thick).

A_1 Horizon.—Thin or absent, frequently represents a mixture of organic matter, ash and mineral soil where A_0 has been burned (0″ to 1″ thick).

A_2 Horizon.—Light grey with pale brown streaks, to very pale brown; platy structure, moderately hard and brittle when dry (6″ to 10″ thick).

B_1 Horizon.—Yellow-brown to brown; massive and compact, breaking to small nutty and coarse granular aggregates (6″ to 10″ thick).

B_2-C_1 Horizon.—Mottled or streaky light and medium grey; moderate content of lime carbonate; faintly laminated structure—may be remnants of original partly banded deposit (6″ to 8″ or more thick).

C_2 Horizon.—Banded dark heavy clay and lighter coloured silty to gritty clay; small stones present and occasional small boulders; moderate lime content.

Garrick Brownish-Grey Podzolic Profile:

A_0 Horizon or Mixed A_0-A_1 Horizon.—2″ to 3″ thick.

A_2 Horizon.—Pale brown to brownish-grey, giving cultivated soils a distinctly more brownish tinge than shown by the grey podzolic soil; platy structure, crushing to fine granular (6″ to 10″ thick).

B_1 Horizon.—Light brown to light yellow-brown (buff coloured); coarse granular structure, less compact and hard than in grey podzolic (6″ to 8″ thick).

B_2 Horizon.—Light greyish-brown; massive to faintly laminated; soft and friable; moderate content of lime carbonate (8″ to 12″ or more thick).

C_1 Horizon.—Grey to light grey; gritty, calcareous clay; sometimes it is difficult to separate B_2 and C_1 horizons.

C_2 Horizon.—Banded dark grey clay and light grey gritty, limy clay; this type of profile seems to be associated with the presence of a greater proportion of the lighter coloured calcareous clay.

Garrick Podzolic-Solonetzic Profile:

A_0 Horizon.—As described above.

A_1 Horizon.—As described above—thin or absent.

A_2 Horizon.—Light grey to grey; thick platy structure, hard when dry (4″ to 10″ thick).

A_3 Horizon.—Brownish-grey; thick platy-nutty structure; podzolic leaching of former B horizon; not always present (0″ to 4″ thick).

B_1 Horizon.—Dark brown to greyish-brown; waxy appearance; massive heavy clay with cleavage into columns when dry, breaking to cubic and angular fragments. The top of the B_1 has a slight to well developed round-top structure. This horizon exhibits a wave-like form or undulation in road cuts—approaching the surface in one place and then dipping to a lower level. This causes corresponding variations in the thickness of the A horizons (8″ to 12″ thick).

B_2 Horizon.—Grey-brown to yellow-brown; massive, breaking to granular aggregates; slight to moderate lime content; not always present (0″ to 8″ thick).

C Horizon.—Roughly banded dark and light grey clays, with preponderance of the darker, heavier textured material; slight lime content.

The Poorly Drained Podzolic profile is characterized by a somewhat peaty A_0; the A_2 horizon is grey with yellowish streaks. The B_1 is greyish-brown to dark grey, with yellowish to rusty streaks. The lower horizons are mottled with rusty, yellow, bluish-grey colours, indicative of poor drainage.

The Shallow Knoll profile has a very thin A_0 horizon, a thin or absent A_1, and a thin grey to brownish-grey A_2, 4″ to 6″ thick. The B horizons are likewise relatively thin and lime carbonate occurs at a more shallow depth than in the well developed Garrick soils below the knoll position.

Garrick soils are mapped as a complex or mixed soil area with Kelsey, Waitville, and Meadow-Bog soils respectively.

Agriculture.—The brownish-grey and grey podzolic clay loam profiles on well drained topography are the best agricultural types of the Garrick Association. These soils are rated at 57, and the loamy textured profiles at 48. The podzolic-solonetzic profiles are rated at 40 to 48. Thus the best Garrick profiles have a higher rating than the Waitville and Loon River soils which are also developed on boulder clay. However, most of the Garrick soils under cultivation at the time of survey had not been settled very long and there are no long-time records of their productivity. It remains to be seen, therefore, whether the Garrick soils will retain a satisfactory structure and give good yields if they are used continuously for grain production. In the past, alfalfa seed has been produced on many Garrick soils, but at the time of survey observations indicated that less of this crop was being grown. It may be expected that the use of manure or other

sources of organic matter and of fertilizers carrying phosphorus, nitrogen and sulphur will not only be desirable but necessary if these soils are to be kept in a productive state. Straight grain growing is not likely to provide a satisfactory permanent system of agriculture for these soils.

Heavy clearing of trees and in some areas of stones are also handicaps to settlement. Local areas of poorly drained land are also a problem. Erosion is not a serious factor, although slight water erosion was observed on upper slopes of undulating land.

SMEATON ASSOCIATION

Description.—The Smeaton Association consists chiefly of brownish-grey podzolic soils of gritty loam to sandy loam textures. These soils are developed on thin glacio-fluvial deposits overlying and sometimes mixed with heavy lake-modified boulder clay. The Smeaton deposits occur chiefly along the north-easterly edge of the lacustrine deposits occupying the Saskatchewan Lowland. It is probable that the Smeaton deposits occur where the ice front formed the northern shore of the glacial lake. The coarse texture could have resulted from the sorting action of melt waters and also from wave action near the lake shore. In some places masses of heavy boulder clay or lacustrine clay appear to have been thrust upwards and over the sandy deposits. This suggests the action of advancing ice. The glacio-fluvial deposits are often interspersed with lacustrine, aeolian, boulder clay and peat deposits.

It will be apparent from the above statements that the Smeaton soils are associated with wide variations in texture, thickness of profile, and degree of podzolic leaching. Where the soils form a very complex pattern and cannot be separated on the map, they are designated as the Smeaton Complex. The complex is discussed at the end of this section dealing with the Smeaton Association.

The Smeaton Association occurs chiefly in the Smeaton district and extends west to Shipman and east to Choiceland. Small islands of Smeaton soils occur near Henribourg and Albertville. About 40,000 acres were mapped in the Smeaton Association, of which about 16,000 acres are included in the Smeaton Complex.

The soil landscape of the Smeaton Association is characterized by nearly level to gently undulating topography. Local sand ridges and peat depressions give a pronounced micro-relief in many places. The road cuts and cultivated fields show an intricate mixture of sandy deposits, stones, boulders and heavy boulder clay. The surface colour of the cultivated soils varies from grey to greyish-brown to dark brown (peaty). Agricultural development is poor for the most part, although wide variations in the stand of crops are common. On uncultivated land there is a similar wide range of forest vegetation, including a poor stand of mixedwood (aspen, black poplar, spruce), jack pine stands on ridges, and black spruce, willows and peat in depressions.

The topography of the Smeaton Association is chiefly level to very gently undulating, often with a pronounced micro-relief where other soils occur (Smeaton Complex). Only 4,000 acres are mapped in mixed undulating-rolling or strongly undulating topography, and

these areas consist largely of a mixture of Smeaton and Pelly soils. Flat-depressional land is occupied by poorly drained Smeaton soils together with Weirdale and Meadow-Bog soils.

Surface drainage is variable, but in most instances is satisfactory on Smeaton soils. Slow to no free drainage is associated with the Meadow-Bog areas. Internal or soil profile drainage is extremely variable. Excessive drainage of the upper horizons is common in Smeaton sandy loams, with poor to very poor drainage in the underlying heavy textured deposit. Moderately good profile drainage occurs in the Smeaton loam profiles.

Smeaton soils range from stone-free conditions (S_0) to very stony (S_3). In very stony soils there may be a layer of glacial stones and boulders at the junction of the sandy surface deposit. In the gritty loams and some of the sandy loam soils pockets of small stones (cobble) and gravel are common.

Smeaton soils are mapped as loam, light loam, fine sandy loam, and sandy loam textures.

Member profiles of the Smeaton Association include Brownish-Grey Podzolic, Grey Podzolic, Podzolic-Solonetzic, Poorly Drained Podzolic, and Peat Podzol profiles.

Generalized descriptions of some important Smeaton profiles are given below. The Smeaton soils are so variable, however, that it is not possible to cover all profile variations by specific descriptions.

Smeaton Brownish-Grey Podzolic Profile:

A_0-A_1 Horizon.—Usually a mixture of partially decomposed organic matter and mineral soil, frequently including ash from the burning of the forest cover; dark grey to medium grey; loose granular to platy structure (2″ to 4″ thick).

A_2 Horizon.—Brownish-grey often with rusty-yellow-greyish streaks; weak platy structure; fine sandy loam to sandy clay loam texture (8″ to 10″ thick).

B_1 Horizon.—Yellowish to rusty-brown; massive, breaking to irregular cloddy aggregates; moderately compact (6″ to 10″ thick).

D Horizon.—Dark grey to grey heavy boulder clay or lacustrine clay; slight to moderate lime content.

The Smeaton Grey Podzolic profile has little or no A_1 horizon and a very pale brown to grey A_2 horizon of platy structure and ranging from 8″ to 12″ thick. The B_1 horizon tends to be somewhat more compact than that of the Brownish-Grey profile.

Smeaton Podzolic-Solonetzic profiles are characterized by "wavy" or undulating B_1 horizons which have round-topped columnar structure and heavy clay texture. The B_1 horizon ranges from 6″ to 30″ below the surface.

The Poorly Drained Podzolic profiles have relatively dark grey A horizons with spots and streaks of yellow and rusty colours. The B and D horizons are mottled with rusty-yellow-blue-grey colours.

The Peat Podzolic profiles have a surface layer of peat, underlain by greyish, leached A horizons, and wet, poorly drained subsoil horizons.

The Smeaton soils have been mapped as a simple complex with Bodmin, Pelly, Weirdale and Meadow-Bog soils respectively. Where several associations, including Smeaton, occur in close association, they are mapped as the Smeaton Complex. In all areas where Smeaton soils have been mapped it may be expected that local areas of other soils will occur.

SMEATON COMPLEX

As already indicated, this complex is used to designate very complex mixtures of the Smeaton Association with several other soil associations. The important factor in establishing the complex is that the various soils occupy such small areas that they cannot be shown separately on a reconnaissance soil map. In theory, each soil association could be mapped out and separated by a detailed soil survey. Much of the Smeaton Complex, however, could not be separated on any logical scale of mapping that could be employed.

The better type of Smeaton Complex consists of Smeaton-Kelsey and Garrick soils. Poorer combinations include sandy to stony Smeaton soils with Bodmin, Sylvania and Pine soils. The Sylvania and Pine soils usually occupy slight ridges and knolls.

In lower, poorly drained areas Smeaton soils occur with Weirdale, peat-podzol and Meadow-Bog soils.

It will be evident that soil areas shown as Smeaton Complex on the map will require close and careful examination in order to determine the dominant soil associations on any given parcel of land.

Agriculture.—It is difficult to discuss the agricultural value of the Smeaton Association since it so often occurs as a complex with other soils of varying productivity. In general, however, the Smeaton soils are too variable in themselves to make desirable agricultural types. The frequent variations in texture, degree of leaching, and conditions of stoniness are all unfavourable factors. This is particularly true from the standpoint of uniform growth and maturity of crops. Wind erosion on associated Pine and Sylvania soils frequently affects adjacent Smeaton soils. The Smeaton soils have been tentatively rated as follows: loam 48, light loam 40, fine sandy loam 37, sandy loam 34.

It is suggested that forage crops, in a rotation, would be more desirable than straight grain growing on Smeaton soils.

LA CORNE ASSOCIATION

Description.—The La Corne Association consists of brownish-grey podzolic soils of fine to very fine sandy loam textures, developed on sandy alluvial deposits. Some areas of rolling topography may represent a re-working of the alluvial deposits by wind action. The La Corne Association occurs on the Saskatchewan Lowland, chiefly in the areas adjacent to the northern and eastern boundaries of the La Corne Forest Reserve. Small areas of La Corne soils occur north-east of Whitefox and also east of Carrot River. Just under 50,000 acres were mapped in this association.

The soil landscape of the La Corne Association is characterized by topography ranging from nearly level to smoothly undulating and

smoothly rolling. The forest cover is largely aspen with some black poplar and spruce and numerous shrubs. The soils are stone-free and in cultivated fields the surface soils have a pronounced brownish-grey tinge—the colours ranging from pale brown to light brownish-grey. Agricultural development is fair on undulating topography but poor in rolling areas where considerable uncultivated land occurs.

About 25,000 acres, representing approximately 50 per cent. of the La Corne Association, have been mapped as nearly level to gently undulating. 17,000 acres, or about 33 per cent. of the total, are mapped in strongly undulating to mixed undulating-rolling topography. About 6,500 acres are mapped in rolling topography.

Surface drainage is adequate in most La Corne areas, except where flat topography occurs. Such areas are associated with the local occurrence of Meadow-Bog soils. Internal or soil profile drainage is satisfactory to somewhat excessive. Although sandy textures prevail, there is generally a moderately to well developed rather compact B horizon in the upland brownish-grey profile. The podzolized sand profile, however, has little or no compaction in the B. Moderately poor profile drainage occurs in flat-depressional positions, particularly where a heavier textured D horizon is present.

La Corne soils are typically free of stones and gravel.

La Corne soils are mapped as fine sandy loam, very fine sandy loam, and sandy light loam. The use of the term "sandy light loam" is discussed under the Shellbrook Association. It is sufficient to state that the sandy light loams represent sandy clay loam and heavier textured sandy loams. 60 per cent. of the La Corne soils consist of very fine sandy loam textures, and about 25 per cent. of fine sandy loams. The sandy light loam is relatively inextensive.

Member profiles of the La Corne Association include the Brownish-Grey Upland Podzolic, Podzolized Sand, and Poorly Drained Podzolic.

Generalized descriptions of the more important La Corne member profiles are given below:

La Corne Brownish-Grey Podzolic Profile:

A_0-A_1 Horizon.—Dark grey to grey, mixed remnants of organic surface and thin mineral soil (3" to 4" thick). Where undisturbed A_0 is present, A_1 is very thin.

A_2 Horizon.—Light brownish-grey to very pale brown; thick platy or cloddy-platy when dry, crushing to loose structureless condition; fine sandy loam texture (8" to 12" thick).

B_1 Horizon.—Brown; hard irregular cloddy; sandy clay loam texture (8" to 12" thick).

B_2 Horizon.—Yellow-brown; massive, slightly compact, breaking to soft cloddy-fine granular and loose structureless condition (6" to 10" thick).

C Horizon.—Yellowish-grey; loose very fine and fine sand; no lime carbonate.

D Horizon.—Greyish sandy to silty deposit; slight to moderate lime carbonate content; this horizon is not always encountered.

La Corne Podzolized Sand Profile:

A_0 Horizon.—If present consists of leaf litter and partially decomposed organic matter; frequently absent or modified by fire (0" to 2" thick).

A_1 Horizon.—Grey-brown; very thin or absent; may represent organic staining or ash at the top of the A_2 (0" to ½" thick).

A_2 Horizon.—Light brownish-grey to very pale brown; light sandy loam texture; thick platy structure, crushing easily to loose structureless (powdery) condition (8" to 15" thick).

B_1 Horizon.—Speckled brownish-grey; massive to weak thick platy or flat cloddy structure; easily broken down; little or no compaction and only slightly heavier than A_2 (12" to 20" thick).

Remaining horizons similar to those already described.

Moderately Poorly Drained La Corne profiles are characterized by mottled rusty-yellowish-grey A_2 horizons, and mottled B horizons with more rusty and yellowish colours.

La Corne soils have been mapped as a complex or mixed soil area with Sylvania and Carrot River soils respectively. The La Corne soils have a more pronounced brownish colour in the A_2 horizon than is typical of Sylvania soils. Carrot River profiles are not strongly leached and horizon features are less well developed than those of the La Corne Association.

Agriculture.—The La Corne soils occurring on nearly level topography are agriculturally similar to Whitefox soils. The La Corne soils are, however, rated below Whitefox types because they are more strongly leached and hence are lower in native fertility. La Corne sandy light loam is rated at 50, the very fine sandy loam at 44 and the fine sandy loam at 36. La Corne soils are used chiefly for grain production, of which wheat is the principal crop. Coarse grains and some forage crops are also produced. The La Corne soils, even more than the Whitefox, are likely to present fertility problems where only grain farming is practiced. These soils will require maintenance of soil organic matter and good structure, the addition of fertilizers, and the control of wind erosion. Slight to moderately severe wind erosion has been observed on La Corne soils. In areas of rolling topography water erosion is an additional problem.

DORINTOSH ASSOCIATION

Description.—The Dorintosh Association consists chiefly of brownish-grey loamy podzolic soils on silty glacial lacustrine deposits. These soils occur on the Beaver River Plain of the Meadow Lake area. They represent more strongly leached or podzolized Beaver River soils, and occur mainly north and north-east of Meadow Lake. Small scattered areas of these soils occur south-east of Meadow Lake; near Goodsoil; and in the district around Big River. About 32,000 acres were mapped in this association.

The soil landscape of the Dorintosh Association is characterized by very gently to moderately undulating topography—rougher topography being relatively inextensive. The vegetation consists of a medium cover of aspen and black poplar, with peat and sedges and some black poplar in low poorly drained areas. Cultivated soils have a distinct brownish-grey colour. Stones are rare to absent, except where the underlying boulder clay comes close to the surface, or where Dorintosh soils are mixed with the Loon River Association. Agricultural development on Dorintosh soils is good to poor, the best development occurring where Dorintosh soils are mixed with better soils such as Beaver River and Meadow Lake.

Most of the Dorintosh soils occur on very gently to gently undulating topography. Only about 12 per cent. of the total acreage is mapped as roughly undulating to rolling. Local flat-depressional areas occur within Dorintosh soil areas, and these are occupied by Meadow-Bog and Muskeg soils.

Surface drainage is satisfactory except on flatter land adjacent to the undrained meadow and bog areas, where drainage is slow. Somewhat excessive drainage is associated with the rolling topography. Internal or soil profile drainage is good in nearly all Dorintosh soils. Local areas of poorly drained soils occur around the depressions.

Dorintosh soils are typically stone-free to slightly stony (S_0 to S_1). Moderately stony areas occur where the underlying boulder clay is reached in road cuts or by tillage, but such areas are neither large nor very common.

The Dorintosh soils have been mapped as loam and clay loam textures. Almost three-quarters of the total acreage is mapped as loam. One small area was mapped as clay.

Member profiles of the Dorintosh Association consist chiefly of Brownish-Grey podzolic soils. Complex Podzolic-Solonetzic, Grey Podzolic and Poorly Drained Podzolic profiles also occur.

Generalized descriptions of the Dorintosh profiles are given below:

Dorintosh Brownish-Grey Podzolic Profile:

A_0 Horizon.—Partially decomposed organic matter (0″ to 1″ thick). Sometimes this horizon is modified by fire and appears as a mixed A_0-A_1 horizon (1″ to 2″ thick).

A_1 Horizon.—Mixed dark grey, grey and grey-brown; platy structure (1″ to 2″ thick).

A_2 Horizon.—Light brownish-grey to yellowish-grey; platy structure; hard when dry, breaking to powdery very fine granular aggregates (5″ to 8″ thick).

A-B Horizon.—Brownish-grey to yellow-brown; thick platy-cloddy structure, hard when dry (4″ to 8″ thick).

B_1 Horizon.—Dark greyish-brown; small nutty structure, hard; clay texture (6″ to 10″ thick).

B_2 Horizon.—Brown; nutty structure (6″ to 8″ thick).

C Horizon.—Dark grey-brown and lighter yellow-brown to grey; varved lacustrine deposit; moderate lime content.

In other brownish-grey podzol profiles the A-B transitional horizon is absent and the A_2 horizon is sharply separated from the B_1. There may also be a B_3 or C_1 horizon containing lime carbonate.

The Dorintosh Podzolic-Solonetzic profile is characterized by a massive compact B_1 horizon which may be separated into columns when dry, and which breaks into hard cubic to angular fragmental aggregates. A slight round-top development is sometimes noticeable at the top of the B_1, with a thin A_3 horizon above.

Dorintosh Poorly Drained Podzolic profiles have yellowish streaks in the A_2 horizon, and yellow, rusty, blue-grey streaks and spots in the lower horizons. The A_0 ranges from a thick organic mat to a true peat deposit.

Dorintosh soils have been mapped as a complex or mixed soil area with Beaver River, Sylvania, and occasionally Bodmin and Loon River soils, respectively. The Dorintosh-Beaver River complex is most common.

Agriculture.—The Dorintosh soils are among the better agricultural soils of the Grey Soil Zone. In particular, they are superior to Loon River, Bodmin and Sylvania. On the other hand, they are rated below the Beaver River, Meadow Lake and Makwa soils. The Dorintosh clay loam is rated at 61 and the loam at 53.

Dorintosh soils are used principally for grain production, although alfalfa seed and some forage crops are also grown. The Dorintosh soils have given satisfactory results in straight grain production. It is probable that their well drained condition and their relatively low organic matter content are factors in securing early maturity of wheat and other grains. This is important in an area subject to early fall frosts. It is, however, a reasonable assumption that continuous grain production alone will not keep these soils in a state of good structure and satisfactory level of fertility. The relatively low content of nitrogen, organic matter, phosphorus and lime in these soils will ultimately lead to the greater use of legume crops, manure and fertilizers.

Miscellaneous Soils

The undifferentiated soil associations and soil complexes of the present surveyed area have been mapped in the following groups:

Alluvium	Meadow-Bog Complex
Meadow Soils	Undifferentiated Sands
Saline (Alkali) Soils	Dune Sands
Peat (Bog) Soils	Eroded (Truncated) Soils

Depression ("Bluff") Podzol Soils

The above soils were classified as Miscellaneous Soils because they represent types that for various reasons could not be placed in established associations. In the first place, some soils have such weakly developed profiles or are of such recent origin that they lack well developed profile and horizon features. Alluvium, Dune Sands, and Undifferentiated Sands belong to this class.

Other soils are so strongly influenced by more or less permanently wet subsoil conditions that they form a distinct group of groundwater soils, which only in part reflect the influences of the regional climate. However, the most important reason for classifying these soils as Miscellaneous is that the broad scale of mapping did not permit the separation and recognition of the wide variety of soil profiles present in local areas. Meadow, Muskeg, and Meadow-Bog soils represent this group.

Saline soils can usually be classified according to the soil zone to which they belong but are difficult to separate according to texture and parent material on the broad scale of mapping used in the survey. This difficulty prevented the classification and mapping of small local areas of saline soils.

PLATE 28

Unfertilized wheat in strip to right of figure. A strong response to 11-48-0 fertilizer, affecting maturity as well as yield.

Fertilizer response on clovers depends upon sulphur. The strong response in left of picture was obtained from applying a sulphur carrying fertilizer.

Eroded soils represent a complex of recognized soil associations in which many of the profiles are modified by erosion. Accumulations of materials eroded from soils on higher land are also present, and in some instances underlying glacial and pre-glacial sediments are exposed.

Finally, a description of Depression ("Bluff") Podzols is included, although these soils occupy such small local areas that they cannot be shown on the soil map.

From the agricultural standpoint most of the Miscellaneous soils are of low value. The Meadow and Meadow-Bog soils are potentially good agricultural soils when they are reclaimed by drainage. Alluvial soils are also arable types if not too poorly drained. The remaining soils vary from poor to non-arable types. The various groups of soils listed as Miscellaneous Soils are discussed individually in the following pages.

ALLUVIUM

Description.—Alluvium is used to describe weakly developed soils on variable textured alluvial deposits of river and creek flood plains. In this present survey only the larger areas could be shown on the soil map, but narrow bands of Alluvium also occur along many of the smaller streams. The larger areas of Alluvium occur along the Saskatchewan River, near Prince Albert and below Nipawin respectively. Alluvium has also been mapped along Big Gully Creek and along several of the streams that dissect the Turtleford Plain.

As already stated, soils classified as Alluvium have weakly developed profiles. The parent material deposit consists of alluvial clays, silts and sands laid down by streams during periods of flooding. Changes in the position and velocity of the stream throughout its existence cause variations in the type of material deposited. Thus most areas of Alluvium consist of layers or strata of variable textured sediments. The vertical arrangement of these layers gives a false impression of a soil profile with its various horizons.

Where profile development can be observed saline-solonetzic and columnar types appear to be most common. The development of horizons is generally restricted to the surface layer, and the whole profile may not exceed a few inches in thickness. Where better developed profiles occur it may be considered that the area is now above the level of periodic flooding. The least development of a soil profile occurs on the lands still subject to erosion or deposition during periods of high water. Local areas of Meadow and Shallow Peat soils may occur within the flood plain. Although all ranges of texture may occur in Alluvium, medium (loamy-silty) and heavy (clay) textures predominate.

Agriculture.—Soils classified under Alluvium vary from fair pasture to good arable types. Since the variations in texture and degree of profile development could not be separated on the present map, it is not possible to discuss the agricultural value and rating of these soils in detail. In the present area the Alluvium along the Saskatchewan River near Prince Albert represents young or immature black soils of moderate to good drainage and of high native fertility. At the

other extreme, the Alluvium along some of the streams on the Turtleford Plain is mixed with wet marshy areas, stony soils and rough, stream dissected lands, so that no large areas of arable soil exist.

It should be mentioned that many of the Alluvium areas occurring along smaller streams are suitable for cultivation or for the production of native hay.

SALINE (ALKALI) SOILS

Description.—Saline soils consist of undifferentiated soils characterized by moderate to excessively high contents of soluble salts (alkali). In the present area no large belts of Saline soils occur such as those found in the more arid parts of the Province. The areas of Saline soils large enough to show on the map are confined to the Lloydminster Upland, where about 700 acres were mapped. There are innumerable saline depressions or sloughs throughout the Lloydminster, Waseca and Onion Lake soils. While these could not be shown on the map, they are very important features of many individual farms.

It is difficult to detect saline soils in the Black and Transition Soil Zones, where the soils are frequently moist throughout and particularly where the salts may be concentrated in the subsoil. Certain native plants may serve as indicators of salty soils. These include salt grass, Nuttal's alkali grass, wild barley, and others.

There are two kinds of alkali soils, namely "White Alkali" and "Black Alkali." White Alkali soils contain an excess of such common soluble salts as Glauber's salt (sodium sulphate), Epsom salt (magnesium sulphate) and common salt (sodium chloride). "Black Alkali" is caused by the presence of ordinary washing soda (sodium carbonate), which imparts a distinctly alkaline reaction to the soil. This type of alkali is rarely encountered in Saskatchewan. Black Alkali is much more toxic to plants than is White Alkali, a small amount being sufficient to seriously affect plant growth.

In the Black Soil Zone, Saline soils of the White Alkali type may be detected by whitish spots, streaks, or solid bands of salts occurring in the profile. When the soil is wet the light colours disappear. In very wet periods the salts may dissolve and move downward into the lower horizons. In dry periods the salts tend to concentrate nearer to the surface, and may even form a white crust. These variations are no doubt responsible for the belief that "Alkali" spots grow in some years and shrink in size in other years.

Saline soils show little profile development. To some extent they reflect their zonal position by the colour and associated organic matter content of the A horizon. In very salty soils there is a tendency for loose granular structure ("puff" spots) at the surface or wherever the salt concentration is greatest. From the surface downward the most common sequence of colours is dark grey over light grey to bluish-grey, over mottled grey, bluish-grey and yellow.

Saline soils occur chiefly on flat to depressional areas where natural drainage is very poor. Such areas consist largely of shallow lake beds, ponds or sloughs and poorly drained stream channels and

flood plains. Hence, many saline soils are developed on relatively recent alluvial and pond deposits. They are, however, also found on sloping uplands, notably where seepage occurs above impervious beds. Particularly heavy concentrations of salts may occur where seepage comes from weathering Cretaceous shales. It is probable that the salts associated with the Onion Lake Association are derived in this manner.

Agriculture.—Saline soils with very high concentrations of salts are unsuitable for ordinary cultivation. Soils with moderate to high concentrations may be used for the production of tolerant crops—such as sweet clover, slender wheat grass, barley and oats. This statement presupposes that the soil is otherwise suitable for cultivation, particularly in regard to drainage. The use of manure and the ploughing down of green crops are recommended practices. The use of sweet clover is particularly recommended since it will tolerate a high salt concentration. It should be noted that wheat and flax are very sensitive to alkali salts. So, too, are many garden and fruit crops. Saline (alkali) land should be avoided as a site for the home garden.

MEADOW SOILS

Description.—Meadow soils consist of undifferentiated soils on wet alluvial and pond deposits. Compared with upland soils, Meadow profiles lack well developed structure but features indicating poor drainage are very pronounced.

Meadow soils occur principally in the Black-Grey soil areas, and in the neighbouring portions of the Black and Grey Soil Zones respectively. Further south Meadow soils give way to saline or other types of soils found in ponds or sloughs and dry lake beds. In the Grey Soil Zone, Meadow soils are largely replaced by Peat (Bog) soils. In the present survey about 130,000 acres were mapped as Meadow soils. Such soils are most common on the Debden Plain and around Witchekan Lake on the Coteau Upland.

Meadow soils are confined to flat-depressional topography where surface and profile drainage conditions are very poor. The native vegetation consists mainly of marsh grasses and sedges with rushes and cat-tails in the wetter areas. As Meadow soils dry up or are drained, willows tend to invade the area.

Meadow profiles vary in texture, thickness of the A horizon and reaction, and include calcareous or high lime to leached (degraded) types. The calcareous (limy) Meadow profile has a dark A horizon, associated with a high content of soil organic matter. There is frequently a partially to well decomposed layer of peat at the surface (muck-like horizon). The dark A horizon is flaked with whitish lime carbonate material and numerous small shells are sometimes present. The A horizon has a granular to soft cloddy structure and varies from 6" to 15" in thickness. The B-C horizon is mottled with grey, blue-grey and yellow colours and speckled with rusty and brownish spots. A moderate to high content of lime carbonate is characteristic. Separation of clearly defined horizons is difficult. In some places the underlying boulder clay may be encountered at 3 or more feet below the surface.

The leached Meadow soil may vary from a profile having no lime carbonate in the A horizon to a profile with a well developed greyish leached A_2 horizon. Generally speaking, calcareous (limy) Meadow soils are most common in the present surveyed area. Many areas of Meadow soils occur as a complex with Shallow Peat, and Muskeg (Deep Peat or Bog) soils.

Agriculture.—Meadow soils in their original state are too wet for continuous cultivation and cropping. Many Meadow areas were used, and are still used, solely for native hay production. Some of them were cultivated during "dry" periods, only to be abandoned when "wet" seasons returned. Since 1930, however, many new areas of Meadow soils have been brought under cultivation. Two factors have been responsible for this development. First, there has been a general recession, or drying up, of the surface water in streams, lakes and meadow-marshy areas. This removal of water is due partly to a period of low precipitation in the 1930's and partly to the effects of clearing and burning the original vegetation and the drainage due to road construction. How far this change will be a permanent one is not known. Secondly, artificial drainage of Meadow-Bog areas has permitted agricultural settlement of former permanently wet soils.

Where drainage is well established many Meadow soils are essentially similar in agricultural use to the soils of the Weirdale Association. Much still remains to be done in finding the best methods of handling Meadow soils and the most desirable crops to use. The possibility of improving the quality of forage on some of the native hay flats is a problem worthy of attention. If good quality grasses and legumes could be established many northern settlements would be in a better position to raise livestock.

MUSKEG (DEEP PEAT OR BOG) SOILS

Description.—Peat or Bog soils are developed on organic deposits (plant material) accumulated in former shallow lakes and ponds and other wet, undrained depressions. These soils are, therefore, distinct from the soil associations so far described in that they are derived from former living plants or organic matter. They are known as **organic** soils, to distinguish them from the more common **mineral** soils which are derived largely from weathered rock.

In the present survey two groups of Peat soils were mapped: Muskeg (Deep Peat or Bog) soils and Shallow Peat (Half-Bog) soils. From the practical viewpoint the Muskeg soils represent thick Peat deposits, usually only slightly decomposed and occurring in very wet positions; hence these soils are primarily unsuitable for cultivation. The Shallow Peat soils represent thinner organic deposits which can be more easily incorporated with the underlying mineral soil. Drainage may be necessary before Shallow Peat soils can be brought under cultivation, but in general the agricultural development of these soils is more easily accomplished than that of the Deep Peat or Muskeg.

From the standpoint of soil classification the Deep Peat soil represents a soil profile developed entirely on organic deposits. At some depth an underlying mineral deposit will occur but this represents a different geological deposit or D horizon. The Shallow Peat,

on the other hand, consists of an organic layer overlying a mineral deposit that has been modified by soil forming processes.

In addition to the two main groups referred to above, there are other varieties or types of organic soils, depending on the kinds of plants involved, the degree of decomposition of the plant remains, and the reaction of the deposit. The latter term covers the presence or absence of acidity, and the deposits may be thus defined as alkaline, neutral, or acid in reaction. In the broad scale of mapping employed in the present survey it was not possible to make a detailed separation of the various Peat profiles and they are, therefore, classified as undifferentiated organic soil associations.

In the present surveyed area a total of 155,000 acres were mapped as Muskeg. Most of the Muskeg soils represent organic deposits of 2 to 4 feet or more. Types under acid sphagnum moss, under mixed sphagnum, tamarack, black spruce, and Labrador tea and other shrubs are most common. The organic matter is undecomposed at the surface and slightly decomposed to highly decomposed (muck-like) below. The highly decomposed layer, if present, usually occurs at the bottom of the organic deposit, just above the underlying mineral D horizon. Depending upon the type of vegetation that existed at various stages in the development of the peat deposit, moss, fibrous peat, and woody peat may be encountered. Frequently the deposit is a mixed peat in which all of the above types may be represented. Fibrous peat is associated with a former vegetative cover of sedges, grasses and other marsh plants. In woody peat the remains of trees can be identified.

A small peat bog in a glacial kettle or deep slough was examined north of Loon Lake. The profile is described below:

Vegetation.—Sedge, some grasses and small willow, with some moss.

Horizon 1.—Brown, fibrous peat; wet (12" thick).

Horizon 2.—Woody peat; soft decomposing roots, trunks and branches of trees (6" thick).

Horizon 3.—Black muck, very wet (6" thick).

D Horizon.—Mottled dark and light grey, blue-grey and yellowish (gley-like horizon); stony till; very wet.

Another Peat profile on a long 2% to 3% slope was examined north-east of Nipawin and is described below:

Vegetation.—Tamarack, Labrador Tea, sphagnum moss, and, in pockets of open water, reed grass.

Horizon 1.—Light yellow-brown raw sphagnum moss (10" thick).

Horizon 2.—Dark brown decomposing peat and woody fragments (2" thick).

Horizon 3.—Very dark brown mucky peat, occasional woody fragments at top (24" thick).

D Horizon.—Sandy deposit, saturated with water at 3 feet.

Thicker peat profiles also occur, ranging up to 4 feet or more in thickness.

Utilization.—As already stated, Muskeg soils are not suitable for agriculture in their original state. Drainage is required before any attempts at cultivation can be made. The tasks of clearing the trees and shrubs and of working the peat into an arable state are the next problems to be solved. The common practice of burning the peat is

not recommended. Burning the peat means the loss of valuable organic matter and nitrogen. There is also the danger that a complete burn will expose a relatively infertile or poorly productive mineral D horizon. Coarse sandy to stony deposits make particularly poor agricultural soils when the overlying peat deposit has been destroyed. On the other hand, to retain a thick peat deposit and bring it into a productive state takes a long time and requires special management and equipment. Finally, some of the sphagnum peats are moderately to highly acid in reaction, a condition which interferes with the proper decomposition of the peat and may also adversely affect the growth of some crops.

The reclamation of peat soils as drainage and clearing proceed is likely to continue and where this results in the formation of good arable land the process is justified. On the other hand, natural peat deposits play a valuable part in the storage and conservation of water. Under a combination of natural forest and peat cover, precipitation is intercepted by the leaves and branches of trees, and enters the soil with little or no erosive force; the peat bogs act like gigantic sponges, soaking up the excess water and holding it in storage. This water is slowly released to streams and drainage basins thus helping to maintain the level of streams and local water tables, and again preventing the erosion that occurs when large volumes of water are suddenly spilled into a stream channel. The latter condition is more likely to occur where large areas have been cleared of forest and peat cover. As a result dangerous and sometimes costly floods are let loose in the spring thaw or following heavy precipitation, followed by a period when the streams become a mere trickle or dry up until the next flood.

It is important, therefore, that only peat soils suitable for agriculture should be reclaimed and cultivated. Deep Peat soils that constitute poor agricultural types or whose reclamation cannot be satisfactorily accomplished, may serve the province better as permanent muskegs or bogs. Where large areas are involved it is particularly important that, in addition to the soil classification, information be secured on the desirability and feasibility of drainage. This latter information requires the technical services of the forester and the engineer.

SHALLOW PEAT SOILS

Description.—As stated in the previous section, dealing with Deep Peat soils, the Shallow Peat soils represent a relatively thin organic deposit overlying a mineral soil. In the present surveyed area Shallow Peat soils have not been mapped by themselves. The larger areas of Shallow Peat soils are found in combination with Meadow soils, and hence are mapped as the Meadow-Bog complex.

Shallow Peat soils vary in the same way as the Deep Peat—that is, the peat deposit varies according to type of vegetation, degree of decomposition and reaction. In addition, the Shallow Peat profiles must be partly classified according to the kind of mineral soil developed underneath the peat. These soils may, therefore, be regarded as organic-mineral soils.

The majority of the Shallow Peat soils encountered in the present surveyed area are non-acid types, and include alkaline to calcareous

profiles—the latter indicating the presence of lime carbonate. There are, however, acidic profiles, ranging from leached Shallow Peat, which contains no lime in the organic layer or in the upper mineral layer, to the podzolized peat in which a greyish leached A_2 mineral horizon occurs immediately beneath the peaty surface. Other varieties of Shallow Peat soils include the profile developed from sedge-grass vegetation. This profile has a fibrous peaty layer at the surface over a dark, highly decomposed muck-like horizon. Beneath this is a dark mineral horizon overlying a lighter coloured, mottled and poorly drained mineral soil. Partial descriptions of some of the Shallow Peat profiles are given below:

Calcareous Shallow Peat:

Horizon 1.—Brown fibrous peat, raw to slightly decomposed; usually lime-free (3" to 12" thick).

Horizon 2.—Very dark brown to dark brown; moderately decomposed sedge peat; not always present (0" to 8" thick).

A_1 Horizon.—Very dark brown to nearly black; mucky-mineral soil, high in organic matter; lime-free to moderately limy (calcareous) (2" to 6" thick).

B Horizon.—Light grey to yellowish-grey, mottled with rusty and bluish-grey colours; moderate to high lime content; it may not be possible to identify other horizons below this.

A deeper profile of the calcareous Shallow Peat, with a thicker organic layer, is described under the Carrot River Association (page 129).

Leached Shallow Peat Profile:

Peaty Horizon.—Brown raw peat (4" to 12" thick).

A_1 Horizon.—Dark brown to very dark grey; mineral soil with high organic matter content (1" to 3" thick).

A_2 Horizon.—Medium grey to brownish-grey mottled rusty-yellow-blue-grey; no lime carbonate (4" to 8" thick).

B-C Horizon.—Mottled lighter grey; calcareous mineral soil.

Peat Podzol Profile:

Peat Horizon.—Raw to slightly decomposed peat (6" thick).

A_1 Horizon.—Dark to medium grey (0.5" thick).

A_2 Horizon.—Grey, with rusty streaks; platy structure (5" thick).

B_1 Horizon.—Mottled rusty-bluish-grey; massive structure, moderately compact (6" thick).

B_2-C Horizon.—Mottled, less rusty than B_1 and less compact; extends to 32" from surface.

Fibrous (Sedge) Shallow Peat Profile:

Peaty Horizon 1.—Brown raw peat; fibrous; no lime (6" thick).

Peaty Horizon 2.—Dark brown partially decomposed peat; slightly calcareous or limy (8" thick).

Peaty Horizon 3.—Nearly black mucky peat; moderate lime content (4" thick).

A_1 Horizon.—Very dark grey mineral soil; slight lime content (2" to 4" thick).

B-C Horizon.—Mottled rusty-yellow-greyish clay; moderate lime content (22").

Utilization.—The Shallow Peat soils in most instances can be brought under cultivation more easily than the Deep Peat or Muskeg soils. The thinner depth of raw peat, and the presence of well decomposed or muck-like peat below tends to facilitate the incorporation of the raw peat with the mineral soil, and to hasten its further decomposition. Thus the soil acquires satisfactory physical and chemical properties in a few years. It should be remembered, however, that

good drainage must be established in the Shallow Peat areas as well as in the Muskeg areas.

While it is possible to incorporate the organic material with the mineral matter in most Shallow Peat soils, it remains true that burning the peat is still the most popular method of speeding up the process of developing an arable soil. Observations and discussions with settlers have shown that where burning is practiced crop yields are satisfactory for a few years and then decline sharply. As a result the soil quickly becomes a problem and its fertility has to be raised almost immediately. Where the peat is gradually incorporated with the mineral soil, crops are uneven for some years, but eventually more uniform yields are obtained. The well developed sedge peats and others that are calcareous, overlying uniform very fine sandy to clay textured mineral deposits are the best agricultural types. The sedge grass peats often form good native hay lands.

It is suggested that barley and oats are better than wheat, particularly during the period when raw peat is still present. Forage crops such as timothy or brome, mixed with alfalfa or alsike clover are also desirable crops. For alfalfa good drainage conditions must exist. Manuring is beneficial to peat soils. The manure supplies nutrient elements and also stimulates micro-biological activity which assists in decomposing the peat. Commercial fertilizers should also be tested on peat soils. Ammonium phosphates have given good results in some instances. There is also a possibility that peat soils with a thick organic layer may require potash.

The remarks on the value of peat deposits, as made under Muskeg soils, relative to conservation of water and the need to investigate the effects of drainage on the surrounding area, apply also to areas of Shallow Peat.

MEADOW-BOG COMPLEX

This is a mapping unit, established to cover mixed areas of Meadow, Shallow Peat and Muskeg soils, which could not be separated on a reconnaissance type of survey. In general the complex consists chiefly of Meadow and Shallow Peat soils. Local areas of Muskeg soils, wet marshy depressions and scattered small islands of upland soils may also be included. About 500,000 acres were mapped in the Meadow-Bog Complex. In many districts these soils are being drained, cleared (usually by burning) and finally brought under cultivation. Sedge and grassy areas are used for hay production and grazing. The wooded portions are of less value than the open areas as a source of pasture and hay.

In studying or dealing with the Meadow-Bog Complex it is essential to determine the kinds and proportion of soils in any given area. Reference to the foregoing discussions of Meadow, Muskeg, and Shallow Peat soils will assist in the recognition of such soils.

DUNE SAND

Description.—Dune sand represents weakly developed soil consisting of loose sands deposited in the form of dunes by the action of wind. It is generally considered that the sands represent alluvial (water-deposited) material that was later re-worked by the wind.

Texturally, Dune Sand consists chiefly of fine and medium sands as the latter are defined by mechanical analysis (See Tables 21 and 22). The predominance of sand (85% or more), the movement of material by the wind at various times since the first deposition, and the low organic matter content of the soil have all tended to prevent the formation of a well developed soil profile. There is usually a very thin dark coloured surface horizon, one inch or less in thickness. This horizon is a mixture of organic and mineral material or of sand stained by organic matter. Below this horizon is a brownish-yellow to yellowish, loose, structureless sand, sometimes with brownish to rusty coloured streaks. A slight amount of lime carbonate may be present at a depth of 5 feet or more, or the sand may be lime-free. Where present wind erosion is active, the dark surface layer is absent, and only loose, shifting sand remains. It is common to find several thin dark bands occurring at intervals in an exposed vertical cut of a dune. These represent the respective surfaces of former dunes, originally stabilized by vegetation but which were later buried by sand from active or moving dunes.

Dune topography presents a succession of individual dunes, ridges and hollows. The local relief ranges from 10 to 30 feet or more. The surface is very rough, and only very small areas of level land occur between the dunes. Lower and flatter areas, if present, represent heavier textured material, and frequently this forms poorly drained and often saline soils. There are a great many varieties of dunes, and these are classified according to their shape and pattern. All sand dunes have one feature in common—the steepest slope is to leeward of the wind that formed them. When actively eroding, dunes advance to the leeward or downwind side.

The vegetation of Dune Sand areas consists of various grasses and shrubby plants together with clumps of chokecherry and scrubby aspen. Areas of actively eroding dunes are bare of vegetation.

In the present surveyed area Dune Sands occur chiefly on the southern and western borders of the Turtleford Plain, with a few small areas on the Shellbrook Plain. Only 14,000 acres were mapped as Dune Sand. It should be emphasized that other areas of dune topography occur, but in the present survey these represent leached (podzolized) sands, and hence are classified in the Pine Association. Much larger areas of true Dune Sand occur south of the present surveyed area.

Utilization.—Dune Sands are non-arable soils. Their low moisture holding capacity causes them to be droughty soils, and they are also very low in organic matter, nitrogen and mineral nutrient elements. The main factor in rendering the Dune Sands non-arable, however, is the rough nature of dune topography and the certainty that such soils will drift if the protective vegetative cover is disturbed.

Dune Sands can be used to some extent as grazing lands, provided that grazing is strictly controlled and over-grazing is avoided. Over-grazing, particularly by sheep, is likely to start another cycle of active wind erosion. This may lead to the deposition of infertile sand on adjacent arable soils, and also to the active erosion of the latter.

PLATE 29

Well constructed log house in wooded area.

Well developed farmstead on degraded black soil. Note sheltering groves of trees which were saved during clearing operations.

Dune Sand areas are chiefly valuable as game and native plant preserves, and as public domain where undisturbed natural landscapes may be enjoyed.

UNDIFFERENTIATED SANDS

Description.—Undifferentiated Sands consist of loose sands and loamy sands of mixed alluvial-aeolian origin. Texturally these sands are less uniform than the Dune Sand and hence do not form well developed dunes. Under wind action, low hummocky or miniature dune, and low, smooth ridge topography are formed.

The general statements made under Dune Sand regarding weak profile development apply also to Undifferentiated Sands. Where definite profile features occur, the soils will have been classified as Pine, Sylvania, or La Corne types.

In the present survey the largest areas of Undifferentiated Sands occur on the Beaver River Plain, frequently as a complex with Meadow-Bog or Muskeg soils. Smaller areas occur elsewhere, usually in combination with Dune Sand.

Utilization.—Undifferentiated Sands range from definitely non-arable types to soils capable of restricted arable use under a careful system of soil management. The soils most likely to justify cultivation are the loamy sands on smooth well drained topography. If, as sometimes occurs, the sandy soils are underlain by silty-clayey deposits at a depth of four feet or less, the agricultural possibilities are still more favourable.

Such soils should be used for the production of grasses and legumes. The danger of wind erosion and the low level of fertility do not justify the production of cash grain crops.

Except for these better soil types Undifferentiated Sands should be regarded as non-arable types. There are too many poor sand areas still being farmed in Saskatchewan. The statements made under Dune Sand regarding grazing apply also to the non-arable types of Undifferentiated Sands.

ERODED SOILS

Description.—The term "Eroded" is used to cover the complex of soils and other deposits occurring on steep valley slopes and escarpments. Erosion by streams in former times (and which is still proceeding in the channels of present streams) has led to the downward cutting and excavation of deep river channels. Other valleys, now carrying a small stream or creek, were carved by melt-water during the recession of the glacial ice. Steep, abrupt slopes (escarpments) on the upland represent erosion in former times generally resulting from differences in the relief and nature of underlying geological deposits. The major example of a steep escarpment in the present surveyed area is the north-east face of Paradise Hill. The eastern edge of the Missouri Coteau constitutes a more gently sloping and less pronounced escarpment. In the latter feature the longer, relatively more gentle slopes permit the development of soil profiles which can be placed in established soil associations.

In the present surveyed area Eroded soils are found on the steep channels of the Saskatchewan, Beaver, Big, Sturgeon, White-

fox and Torch Rivers. Eroded soils also occur along other streams and glacial drainage channels, notably on the Turtleford Dissected Plain. About 250,000 acres were mapped as Eroded in the present survey. Much eroded land also occurs in Southern Saskatchewan.

On account of the steep slopes most soils are eroded or truncated so that the profiles are thin and frequently lack one or more horizons found in adjacent regional soils. In lower positions eroded material from above has been deposited from time to time so that weakly developed, variable textured soils are formed. There is also the general downward movement of the whole soil mass under the influence of gravity and referred to as "soil creep." Such movements may be very pronounced when the soil is wet and in a frozen or semi-frozen state. This process, known as solifluction, was particularly important in glacial times and may partly account for the large ridges and hillocks found along some of the steeper valley slopes.

Finally, the erosive forces tend to expose both surface deposits and the underlying glacial till or boulder clay, and in some places the underlying bedrock is also exposed. The exposure and resultant mixing of various kinds of deposits further complicates the characteristics of Eroded Soil areas.

Utilization.—The Eroded Soils are non-arable due to steep slopes, rough broken surface, and frequently to the presence of numerous glacial stones and boulders. In the present broad scale of mapping, local areas of arable soil were unavoidably included in Eroded areas. However, as properly defined, Eroded soils are topographically unsuitable for cultivation.

Eroded areas have some value as pasture, and this is enhanced by the presence of water in the rivers below. In the present area most of the Eroded lands are wooded so that the amount of grazing is limited. In the western section of the area, in the Black and adjacent Black-Grey soil areas, grass is more common on eroded slopes. This is particularly true of southward and westward facing slopes, which are frequently too arid for the establishment of a complete forest cover.

Eroded Soil areas are of interest in affording a pleasing variation to the less striking topography of the arable lands. Exposures of bedrock are valuable to geological studies of the area.

DEPRESSION ("BLUFF") PODZOL SOILS

Description.—These soils cannot be shown on the map, since they occupy small scattered areas.

The Depression Podzol soils occupy small depressions in the upland and the outer margin of sloughs and meadows. They occur in most of the Black and Degraded Black soil areas. The Depression Podzols usually develop under clumps of aspen and willow trees, locally known as "bluffs." A somewhat similar profile may be found in wet sedge and grass meadows.

A generalized description of Depression Podzol is given below:

A_0 **Horizon.**—Highly decomposed leaves and other plant residues; very dark brown to almost black (1" to 3" thick).

A_1 **Horizon.**—Usually absent, but when present very dark grey and of thin platy structure (0" to 1" thick).

A_2 Horizon.—Light (ashy) grey, with specks and streaks of rust; platy structure; easily pulverized to loose structureless or powdery condition (6" to 15" thick).

B_1 Horizon.—Very dark grey-brown to dark bluish-grey, streaked with rust; massive structure, hard waxy appearance, breaking to hard nutty aggregates (10" to 20" thick).

B_2 Horizon.—As above, but with more rusty and yellowish colours, and not quite so compact.

At some point, usually three to four feet below the surface, a wet sticky (gley) horizon is encountered. This consists of a mottled rusty, yellow, bluish and grey sandy clay loam. Lime carbonate is rarely encountered in this profile and is never present in the heavy B horizon.

Depression Podzols exhibit considerable profile variation due to differences in parent material and the stage of podzolic development.

Agriculture.—The Depression Podzol soils appear as small greyish depressions in cultivated fields. At first glance they may be mistaken for "Alkali" spots. Where these soils occupy 25 per cent. or more of the arable land they must be regarded as an important factor in the agricultural use of the land.

From the practical standpoint these soils may be regarded as poorly drained grey podzolic profiles. They have all the adverse features of such soils and in addition a more compact and impervious subsoil. In most seasons they produce poorer crops than the surrounding well drained soils.

The Depression Podzol can be improved by the application of commercial fertilizer and manure. In most districts, however, there is little evidence that these soils are receiving any special treatment as yet.

Composition of Soils of the Area

The data presented in the following paragraphs are selected from analyses of typical soils of the area. These data are used for illustrative purposes rather than in any attempt to give complete analyses on all the soils of the area.

Table 8 gives percentages of clay, silt and sand in surface soils of various textures. It will be noted the clay portion is now taken as less than 0.002 millimetres average diameter, rather than 0.005 millimetres. This is in conformation with the International Standards on clay size now used in Canada. On account of this change the silt range is now from 0.002 to 0.05 millimetres. This slight shift in clay and silt range does not appreciably affect the correlation obtained with field texturing, since the larger clay particles (0.002 to 0.005 millimetres) now included in the silt, are probably less sticky when moist than are the smaller sized particles of less than 0.002 millimetres.

From the practical standpoint the most important characteristics of the soil relating to its physical ability to hold moisture, maintain a good tilth, and to resist erosion, are expressed in the amount of organic matter present and in the clay content. Organic matter

(humus) contributes more in proportion than clay to moisture holding capacity but does not give the "body" to the soil that the clay does. Soils high in clay and especially if also low in organic matter may be intractable to work, and slow to drain. This is a factor of importance, especially in the more level lands of the area, where poor drainage may be a decided handicap.

Lighter textured soils with less clay have the advantage of being easily tilled, and of promoting earliness in the crop. This latter factor is of great importance where frost is a hazard. However, light soils are less drought resistant, and in addition may drift readily. Light soils must be carefully farmed so that organic matter is well maintained, and so that soil drifting is prevented. If such precautions are taken the lighter soils can be very productive on account of the generally more favourable moisture conditions of this area as compared to the drier prairie areas to the south. Furthermore, in contrast to the prairies where the best soils are the heavy soils, the best soils of this more northerly area are medium to medium heavy soils. The very heavy soils are "late" soils and also subject to waterlogging when moisture is plentiful or if surface drainage is slow.

The texture of a soil is one of its most important characteristics, and one which is always shown on the soil map. While texture is determined in the field by the "feel" of the soil when moistened, it is nevertheless based on the percentage of sand and clay as determined by mechanical analysis. The field texture and mechanical analysis of representative soils of the area are as shown in Table 8.

TABLE 8.—TEXTURE AND MECHANICAL COMPOSITION* OF REPRESENTATIVE SOILS OF THE AREA (SURFACE 6")

		Percentage Soil Separates		
Association	Textural Class as Determined in Field	Sands .05-2.0 mm.	Silt .002-.05 mm.	Clay Below .002 mm.
Tisdale	silty clay loam	21.8	50.4	27.8
Nipawin	clay loam	34.6	41.4	24.0
Waitville	loam	38.6	49.4	12.0
Smeaton	loam	37.9	44.5	17.6
Shellbrook	light loam	57.3	29.0	13.7
Shellbrook	fine sandy loam	67.0	23.9	9.2

In Table 9 percentages of total nitrogen, potassium and phosphorus, as well as the reaction (pH) are given by soil zones and associations. The figures given for each association represent a number of analyses from which the median** result was selected as representative. The analyses were of samples collected from the surface six inches of cultivated fields.

Perhaps the first interest in this table is a comparison of values of nitrogen and phosphorus by zones. The black soils show the highest nitrogen contents and the grey wooded soils and brownish-grey soils the lowest. The transition soils are intermediate. Since the soil

*Organic matter free basis.

**Median values are middle values for a series of numbers averaged in ascending or descending order . . . in series of 1 to 5, 3 is the median. Median is commonly close to average but not necessarily the average.

TABLE 9.—PERCENTAGE NITROGEN, PHOSPHORUS, POTASSIUM AND pH VALUES OF CULTIVATED SURFACE SOILS (6" DEPTH)

Soil Zone	Soil Association	% Total Nitrogen	% Total Phosphorus	% Total Potassium	pH	
Black Soils	Oxbow	0.34*	0.09*	1.63	6.0	
	Waseca	0.38	0.08		6.8	Median Value
	Lloydminster	0.45	0.10		6.1	for Zone
	Onion Lake	0.36	0.09		5.6	
	Whitesand	0.27	0.06		6.2	%N 0.38
	Meota	0.14	0.04		6.0	%P 0.08
	Blaine Lake	0.45	0.09		7.0	
	Canora	0.41	0.08		7.0	
	Meadow Lake	0.55	0.08	1.55	6.5	
	Whitewood	0.24	0.06		6.5	
Transition Soils (Degraded Black)	Horsehead	0.19	0.06	1.19	6.8	Median Value
	Makwa	0.42	0.08	1.11	6.5	for Zone
	Pelly	0.26	0.06		6.6	
	Kelsey	0.25	0.05		7.1	%N 0.25
	Glenbush	0.25	0.07		6.8	%P 0.07
	Shellbrook	0.26	0.07		6.8	
	Whitefox	0.15	0.06		6.6	
	Nipawin	0.22	0.07		6.8	
	Kamsack	0.27	0.09		7.3	
	Tisdale	0.44	0.08		7.5	
	Beaver River	0.59	0.07	1.42	6.4	
Transition Soils (Wooded Calcareous)	Paddockwood	0.34	0.07	1.40	7.7	Median Value
	Weirdale	0.35	0.07		7.8	for Zone
	Carrot River	0.45	0.06	1.13	7.9	%N 0.35
						%P 0.05
	Waitville	0.13	0.05		6.8	
Grey Soils	Loon River	0.12	0.04	1.51	7.0	Median Value
	Bodmin	0.11	0.05	1.33	6.1	for Zone
	Pine	0.10	0.05		6.4	%N 0.12
	Sylvania	0.15	0.05		7.2	%P 0.05
Brownish-grey Soils	Garrick	0.13	0.04		6.4	Median Value
	Smeaton	0.18	0.04	1.30	7.0	for Zone
	La Corne	0.14	0.06	1.40	6.5	%N 0.15
	Dorintosh	0.15	0.05		7.3	%P 0.05

*Values shown represent median figures from a number of determinations.

organic matter is roughly 20 times the amount of nitrogen present the same statement will hold true for organic matter content. The black soils contain three times as much organic matter as the grey and brownish-grey podzolized soils. This difference is an important one from the standpoint of productivity, both present and future.

A study of individual soil associations shows considerable variation within the zone. In general the light textured soils tend to have less than the average nitrogen content for the zone, while the heavy soils have more. It is possible that the figures shown for the lighter textured soils are lower than they otherwise would have been because of the effects of wind erosion. The Meota soils which are quite low in total nitrogen for the Black Soil Zone (0.14%) have suffered considerable damage from wind erosion.

The values for total phosphorus as given in Table 9 vary in the same direction as do those for total nitrogen. The differences, however, are not so great in degree. As would be expected the lowest values for phosphorus are found in the leached soils of the podzolic kind such as the grey and brownish-grey associations. The median value for the latter is 0.05% as compared to 0.08% for the black soils. While 0.05% is not an extremely low value for total soil phosphorus, it nevertheless is lower than average for soils of the Province. Considered along with total nitrogen and in comparison with the black soils, the figures serve to emphasize the comparatively lower native fertility of the grey wooded and brownish-grey soils.

Potassium is rarely, if ever, a limiting plant nutrient in Saskatchewan soils. The data in this table indicate a good supply of total potassium for the limited number of analyses made. It may be noted that the variation in total potassium is much less than for either nitrogen or phosphorus.

The values for reaction (pH) of these soils range from slightly acid to very slightly alkaline. The neutral point on the pH scale is 7.0. Values below 7.0 are increasingly acid, and values above 7.0 are increasingly alkaline. Thus a moderately acid soil has a pH of about 5.0 and a very acid soil has a pH of about 4.0. A strongly alkaline soil has a pH of 9.0 or above. Alkalinity in this case is chemical alkalinity and should not be confused with salinity of soils commonly spoken of as "Alkali."

None of the pH values given indicate a need of liming for even more sensitive crops such as legumes. A possible exception might be the Onion Lake soil which has a pH of 5.6. In this case, however, a lime layer is found reasonably close to the surface so that it is unlikely that any response to the use of lime would result. It is noteworthy that the range of pH is only from pH 5.6 to pH 7.9 in spite of the fact that some of the soils are leached podzolic types (grey and brownish-grey) while others are calcareous soils carrying free lime even in the surface layers.

The fact that the podzolized soils are close to neutral in reaction in the surface cultivated layers may be somewhat surprising but is a result which has been checked many times. However, such soils while neutral or only slightly acid at the surface may be much more acid in the subsoil horizons (see Table 12, grey soil) and no free lime may occur within three or four feet of the surface. If such soils become more acid under cultivation, it is quite possible that liming may become necessary for crops such as alfalfa in the course of time. One or two fields have been observed where the soil was too acid for the growth of alfalfa or sweet clover. Fortunately, such cases are rare since lime would be an expensive soil amendment in this area.

Values for nitrogen, organic matter, and phosphorus, given for surface samples only, do not fully indicate the amount of these materials in the soil profile. In some cases practically all the nitrogen and organic matter is concentrated within a few inches of the surface, while in others these constituents are distributed to a greater depth in the profile.

Table 10 shows the distribution of nitrogen and phosphorus in the A horizons of representative uncultivated soils. The total pounds per acre of nitrogen and phosphorus are also given. The extreme comparison is between the thick black Meadow Lake soil with relatively high organic matter and nitrogen to a depth of 12 inches, and the grey wooded Waitville soil in which practically all of the nitrogen and organic matter is concentrated in a shallow surface horizon.

TABLE 10.—NITROGEN AND PHOSPHORUS CONTENTS OF A HORIZONS OF REPRESENTATIVE UNCULTIVATED SOILS

Soil Zone	Soil Association	Horizon	Depth in Inches	%N	%P	Total Lbs. of Nitrogen (per acre)	Total Lbs. of Phosphorus (per acre)
Black Soils	Waseca	A_1	4″	0.52	0.09	6,900	1,200
	Meadow Lake	A_1	7″	0.57	0.08		
		A_2	5″	0.12	0.07	13,770	2,730
Transition Soils	Whitewood	A_1	3″	0.46	0.08		
		A_2	4″	0.09	0.03	5,280	1,080
	Beaver River	A_1	4″	0.62	0.08		
		A_2	4″	0.13	0.06	9,000	1,680
Grey Soils	Waitville	A_1	1½″	0.70	0.10		
		A_2	6″	0.05	0.04	4,050	1,170
	Dorintosh	A_1	2″	0.68	0.12		
		A_2	7″	0.05	0.04	5,130	1,560

This table also illustrates that phosphorus tends to be highest in layers which contain high organic matter and nitrogen.

Table 11 provides data of interest regarding the loss or gain in nitrogen which has occurred in some typical soils of the area since cultivation. As already stated there is a consistent ratio of about one to twenty between nitrogen and organic matter in the soil, so that the losses or gains of nitrogen shown are also reflected in the loss or gain in organic matter.

Generally speaking the black soils have been under cultivation for a longer period than have the transition and grey wooded soils so that the comparisons shown are not without bias. However, the loss of nitrogen from black soils is of considerable proportion and indicates the need of attention to the maintenance of nitrogen and organic matter in future farm operations. The tendency for nitrogen to increase on grey wooded soils is one which has been observed before, and at first thought may seem rather extraordinary. The explanation probably lies in the fact that these soils were originally under a forest vegetation which was not conducive to the accumulation of nitrogen and organic matter. Under cultivation and under cultivated crops, even if only grain crops are grown, some slight increase in these constituents may result, since such crops are more favourable to the accumulation of organic matter and nitrogen than is the native forest vegetation. However, even though the percentage accumulating appears to be considerable it should be noted that these soils are still quite low in nitrogen compared to more fertile soils of other zones. Since the grey wooded soils as a general rule are low

in organic matter and nitrogen, attention to improving the status of these constituents in such soils is a prime requirement for their successful agricultural use.

TABLE 11.—COMPARISON OF AVERAGE NITROGEN VALUES FOR PAIRED UNCULTIVATED AND CULTIVATED SURFACE SOILS

Soil Zone	Soil Association	Uncultivated Soils %N	Cultivated Soils %N	
Black Soils	Waseca	0.52	0.38	% loss of nitrogen from 31 cultivated sites.
	Whitesand	0.37	0.26	21% or over 1,750 lbs. per acre.
	Blaine Lake	0.54	0.42	
Transition Soils (Degraded Black)	Whitewood	0.27	0.29	% loss of nitrogen from 54 cultivated sites.
	Shellbrook	0.37	0.28	3.2% or 190 lbs. per acre.
	Kamsack	0.33	0.35	
Transition Soils (Wooded Calcareous)	Paddockwood	0.35	0.29	% loss of nitrogen from 16 cultivated sites.
	Weirdale	0.38	0.37	3.8% or 260 lbs. per acre.
Grey Soils	Loon River	0.10	0.12	% *gain* of nitrogen on 28 cultivated sites.
	Sylvania	0.12	0.15	30.7% or 600 lbs. per acre.
	Dorintosh	0.11	0.17	

While the loss of nitrogen from soils under cultivation may be a serious enough matter, it is not so serious as is the loss of phosphorus which tends to parallel the drop in nitrogen levels. Nitrogen is an element which is returned to the soil in several fortuitous ways, such as in rainfall and through nitrogen fixing organisms of the soil. On the other hand, the loss of phosphorus is only met by a conscious attempt on the part of the farmer to replace phosphorus by the use of phosphatic fertilizers.

Furthermore, some loss of nitrogen may be expected in soils originally high in organic matter when they are first cultivated, but providing the loss is not too great they may continue to be quite productive. The most serious loss of nitrogen and organic matter does not come about as a result of cropping but rather from the effects of erosion, which tends to result in depletion of the soil in these constituents to the point where the resistant structure, water holding capacity, and general productivity is affected.

The data given in Table 12 are of more interest in the scientific study of processes of profile development than they are from the agricultural viewpoint. On the other hand it will be realized that plants extend their roots far below the surface six inches of soil, and that the nature of subsoil layers may greatly affect their growth.

The soils listed in Table 12 were sampled by natural layers or horizons. These horizons are a result of soil forming processes which include leaching (eluviation) from the surface or A horizons, and deposition (illuviation) of leached material in the subsurface or B

horizons. The C horizon may be generally considered as the unchanged (unaffected by surface weathering) parent mineral material from which the soil has formed under a particular environment with respect to temperature, moisture, and living organisms, and over a certain period of time.

Since an acid type of leaching has been involved in the formation of most of the soils listed in the table, the materials which may be expected to show movement from the A into the B horizons are the basic compounds such as Al_2O_3, Fe_2O_3, TiO_2, CaO and MgO. Calcium and magnesium being the more readily soluble are likely to move to lower horizons in the profile than are aluminum and iron. Titanium oxide is very insoluble and shows only slight movement. In more extreme leaching, and especially in lighter soils, much of the calcium and magnesium may be completely removed from the soil profile, and may finally reach ground waters and so be carried away. This is accompanied by an increase in the acidity of the soil due to the lack of sufficient neutralizing bases, of which calcium and magnesium are of greatest importance. The sesquioxides (iron and alumina oxides) on the other hand are less easily removed, and commonly accumulate and remain in the B horizon. Silica (SiO_2) is an acid forming substance and remains insoluble in an acid medium, so takes little or no part in these leaching processes.

The net result of acid leaching is, therefore, a reduction of basic constituents in the A horizon, and an apparent increase in the amount of silica in the same horizon. The reverse occurs in the B horizon, where iron and alumina oxides may accumulate and the apparent amount of silica is decreased in proportion. The molecular ratio of SiO_2 to R_2O_3 (silica oxide to iron and alumina oxide) is therefore indicative of the comparative degree of leaching of iron and alumina and this, together with molecular ratios of silica to alumina and silica to iron, has been calculated for each horizon and shown in the table. Hygroscopic moisture, which relates to colloidal material, loss on ignition, which roughly indicates organic matter content, carbon dioxide (CO_2), total nitrogen (N), total phosphorus (P), and the reaction (pH) of the various horizons are also included in Table 12.

The Waseca soil, which is listed as a Black Solonetzic soil, shows but slight leaching effects except for some accumulation of lime carbonate in the B(ca) horizon. Analyses of other profiles of this type have shown considerable movement of iron and alumina oxides. The Meadow Lake soil shows leaching movement of iron and alumina as well as of calcium and magnesium. The reaction of the Meadow Lake is also more acid in the A horizon than is the Waseca soil.

The two Degraded Black soils, Horsehead and Makwa, both show evidence of a mild leaching of the podzolic kind. This is as may be expected in the earlier stages of the process of podzolization.

The Brownish-Grey and Grey soils (Dorintosh and Loon River) are types of podzolized soils. Considerable leaching is evidenced in the difference of iron and alumina in the B horizon as compared to the A in both soils. However, both soils have a thin A_1 horizon which is well supplied with humus. The Dorintosh soil is slightly acid down to the B(ca) horizon where the presence of free lime accounts for

TABLE 12—ANALYSES* OF SELECTED SOIL PROFILES

Soil Association	Soil Horizon	Depth Inches	Hyg. Moist. 105°	Ign. Loss	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	CO_2	N	P	pH	$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{Al_2O_3}$
BLACK SOLONETZIC SOILS																	
Waseca	A_1	0–4	1.59	8.75	73.21	10.17	3.21	—	1.21	0.94	—	0.31	0.07	6.3	10.2	61.0	12.2
	A_2	4–8	0.96	3.85	77.87	10.83	3.19	—	0.94	0.80	—	0.13	0.05	5.7	10.3	64.9	12.2
	A_3	8–11	0.66	3.05	79.16	9.89	2.93	0.62	1.04	0.80	—	0.10	0.05	6.2	11.5	72.0	13.6
	B_1	11–17	1.31	3.32	75.29	10.70	3.72	0.58	1.02	1.26	—	0.08	0.05	7.3	9.8	53.6	12.0
	B (ca)	23–30	0.91	4.50	76.13	9.22	3.33	0.44	3.80	1.64	—	0.03	0.04	7.8	11.3	61.0	13.9
Meadow Lake	A_0	0–1	8.15	42.72	36.60	9.46	6.33	0.63	1.45	1.11	0.31	2.04	0.16	6.9	4.6	15.6	6.55
	A_1	1–9	6.01	15.00	65.40	4.92	3.24	0.45	—	0.98	0.08	0.60	0.11	5.3	16.0	55.0	22.7
	A_2	9–15	1.36	3.58	77.45	7.67	5.94	0.70	0.96	0.86	0.04	0.10	0.04	5.4	11.5	35.0	17.2
	B_1	15–25	3.58	4.44	65.35	16.56	5.40	0.84	0.89	1.86	0.43	0.10	0.04	6.0	5.5	31.2	6.7
	B_2	25–35	3.25	4.06	56.85	17.34	4.65	0.66	8.60	1.20	3.98	—	—	7.6	4.7	32.4	5.5
DEGRADED BLACK SOILS																	
Horsehead	A_{1-0}	0–6	2.62	12.00	73.00	8.52	3.27	0.58	1.33	0.84	0.02	0.49	0.07	6.0	11.7	59.8	14.5
	A_2	6–12	1.13	2.39	81.25	9.04	3.58	0.52	0.92	0.87	0.02	0.06	0.03	6.0	12.2	61.3	15.2
	B_1	12–27	2.11	2.38	74.50	11.39	4.53	0.58	0.99	0.98	0.06	0.04	0.04	6.6	8.8	44.3	11.1
	B_2	27–30	2.23	2.23	75.45	9.80	4.15	0.43	2.54	1.72	1.00	—	—	7.7	10.3	48.5	13.1
	B_3	30–36	1.40	1.40	73.90	9.82	3.67	0.53	1.11	0.73	1.76	—	—	7.9	10.3	53.5	12.8
Makwa	A_1	0–7	2.45	9.82	72.15	8.16	4.15	0.52	2.44	1.43	0.01	0.48	0.08	6.4	11.3	46.2	15.0
	A_2	7–10	1.14	3.59	81.58	7.37	3.68	0.48	1.73	1.25	0.01	0.06	0.05	6.1	14.4	59.2	18.9
	A_3	10–13	0.69	1.69	82.80	6.99	3.96	0.43	0.72	0.69	0.13	0.04	0.03	6.3	14.7	55.2	20.0
	B_1	13–20	1.77	2.21	78.35	10.26	4.61	0.41	0.79	1.07	0.10	0.05	0.04	7.0	10.0	45.1	13.0
	B_2	20+	1.07	5.59	70.80	7.70	3.28	0.44	7.29	1.52	3.06	0.02	0.04	8.3	12.3	56.2	15.7
BROWNISH-GREY PODZOLIC SOIL																	
Dorintosh	A_0	0–2	7.99	37.38	49.60	6.56	2.28	0.49	3.19	0.84	0.39	1.28	0.16	6.7	10.7	59.0	12.9
	A_1	2–4	3.20	12.75	69.75	9.07	2.97	0.62	1.52	0.96	0.23	0.45	0.13	6.0	10.7	61.0	13.0
	A_2	4–10	0.67	1.72	81.55	8.77	2.85	0.61	1.05	0.74	0.29	0.04	0.04	5.7	12.1	70.0	14.7
	A_2B_1	10–16	1.71	2.29	78.00	10.49	3.77	0.62	1.07	0.94	0.28	0.05	0.04	5.2	7.7	54.0	8.9
	B_1	16–31	4.06	5.05	66.18	15.98	6.83	0.92	1.12	1.86	0.25	0.08	0.06	5.7	5.5	25.6	7.0
	B (ca)	31–36	2.56	5.13	61.15	14.80	5.46	0.82	4.54	1.15	2.20	—	—	7.6	5.7	30.0	7.04
GREY PODZOLIC SOIL																	
Loon River	A_0	0–1	7.16	39.50	42.60	4.78	1.32	0.36	3.36	0.63	0.34	1.51	0.11	6.4	12.9	88.7	15.1
	A_1	1–2	3.74	20.05	66.60	6.80	1.83	0.47	2.14	0.55	0.23	0.70	0.10	6.0	14.2	101.0	16.6
	A_2	2–11	0.40	1.02	85.55	7.98	2.04	0.63	0.95	0.52	0.17	0.03	0.03	6.5	15.7	110.0	18.3
	B_1	11–20	2.32	2.81	74.45	12.49	5.14	0.52	1.10	1.18	0.07	0.05	0.03	5.0	8.05	38.4	10.1
	B_2	20–34	1.98	2.11	77.00	10.95	4.27	0.46	1.13	1.04	0.07	—	—	5.1	9.70	48.1	12.1

*SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO, and P by fusion methods.

the slightly alkaline pH of 7.6. The Loon River soil is more acid, showing moderate acidity in the B_1 and B_2 horizons. It is not unusual to find the strongest acidity in the upper B horizon of such soils. There is also a slight indication of movement of humus into the upper B horizon in these soils, a condition which has been encountered in analyses of other podzolic soils of the area, where leaching processes are more intensively expressed.

Profile descriptions of soils similar to those listed in Table 12 will be found under the description of Soil Associations, page 52.

Soils and Agriculture

Of the many factors affecting the success of a farmer, none is of greater importance than the character of the land which he farms. The climate of the region more or less determines the variety of crops to be grown, but within that region, the kind of soil, the topography, the amount of stones or other obstructions, are all factors in determining the success of an individual operating a particular farm.

The area mapped and included in this Report has a cooler and moister climate than the prairies lying to the south. Drought is, therefore, a less serious problem and drought resistance of the soil a less critical requirement than it is in the drier areas. In the northeastern section, crop failure due to drought is rare, but in the northwest, extending from Shellbrook to Turtleford and Waseca, low production due to partial drought is not uncommon. Consequently, good texture is desirable here as in areas farther south, although light sandy soils are notably more productive in this moister northerly area than they are on the drier plains, and lighter textured soils also tend to be earlier soils. This is an advantage where the risk of early frosts is commonly a serious one. Crops on heavy textured soils, on the other hand, are likely to be later and, therefore, more subject to frost damage. In addition, heavy soils of rather flat topography are likely to suffer from lack of drainage in this area.

In general, the better soils of the area are medium to heavy textured soils with gently sloping topography which gives sufficient drainage without excessive run-off. Examples of such soils are found in the Lloydminster, Blaine Lake, Meadow Lake, Kamsack and Tisdale Associations. This is in contrast to the prairie area where the best soils are the heavy clays of the Regina and Sceptre Associations. Both the texture and topography of these soils would prove rather unfavourable in the moister areas in the northerly sections of the Province.

There are other points of contrast between the present area and the area south of Township 48. In the first place, nearly all farmers established in the area north of Township 48, and within the area of the present survey, had to clear some bush from their land. In many districts, every acre had to be cleared of trees and brush before breaking could be done. On the prairies, the only obstruction to breaking was due to stones where they occurred. In the north, frequently both stones and bush had to be cleared before breaking could

PLATE 30

Active wind erosion north-east of Prince Albert. Village in background obscured by drifting soil.

Active water erosion in cultivated land. Spring run-off caused most of this gullying.

be done and the land made ready for crop. Another handicap is the difficulty of establishing roads by which market points can be reached. A trail through the bush is not like a trail on the prairie. One might find a way around a mudhole on the prairie, but in the bush the trees prohibit passing around obstructions on the trail except through a great deal of effort by the traveller. Such factors as the difficulty of clearing the land, of establishing roads, and the apparent isolation of a settler in a forested region, have made pioneering over much of this northern area a longer and even more trying experience than was the pioneering of the prairies.

The earlier lands settled in the present area were the rich black lands of the "park belt." Clearing such soils was generally not so difficult a task since open glades were commonly present between the poplar "bluffs." However, as settlement moved into the true forest area, not only was greater effort expended in clearing the land, but in many cases a totally different kind of soil was encountered which was not nearly so high in native fertility as was the black soil. This soil was often a light ashy grey in colour with a tendency to "bake" or form a hard crust upon drying. Such soils are commonly found under forest cover in a cool moist region. These soils are locally spoken of as "white clays," "white muds," or "grey wooded" soils. The latter term is the one more commonly used and is the designation given them in this report. They belong to a world group known as the podzolic soils. It is of interest to mention that "podzol" is a Russian word which might be freely translated as meaning "ash-like." In dry periods such soils are quite powdery, and light grey in colour, hence the Russian designation of ash-like soils.

In the sections to follow, there will be some further discussion of the problems of development, and of matters relating to the maintenance of fertility and land utilization within the area.

CLEARING AND BREAKING

As already indicated, the amount of clearing of both stone and bush is a variable factor. In general, stones occur most commonly on rolling or hilly areas of a morainic nature. The forest, on the other hand, occupied nearly the whole of the area. Clearing bush land has, therefore, been a greater problem than clearing stones. Where both occur the cost is, of course, greatly increased. Unfortunately, it is difficult to estimate the amount of stone in bush land where the leaf fall covers the surface, and scrubby undergrowth obscures the view. In some cases, land has been cleared which was later found to be too stony for breaking, or after an attempt at cultivation, has been abandoned because of excessive stoniness.

Most of the clearing until recent years has required a great deal of hand labour. This is a slow and costly process. The temptation to use fire as a means of clearing land was, therefore, very great and was often practiced with disastrous consequences when the fire became uncontrollable. Much good merchantable timber was lost due to fires originating in this way. However, the settler must not be too harshly criticized since he could not make a living until he had a reasonable acreage under cultivation, and he could not break the land until it was cleared.

The clearing of bush land is a slower process than most people realize, and of course, individual farms could only become self-supporting as a sufficiently large acreage was brought under cultivation. Furthermore, the community could only develop its services and amenities as the land was brought into a productive state.

Economic studies* indicate that in a typical wooded area, the average rate of clearing and breaking has been a little over five acres per year, and that on the average it requires twelve to fifteen years before the farm is self-sustaining (has over 70 acres under cultivation). From the minimum size of about 70 acres required to meet operating expenses, there is an increase in net income with increasing acreage under cultivation.

The use of power equipment is now replacing much of the hand labour formerly required in clearing land, and has greatly increased the possible rate of developing bush land. However, the cost remains quite high. Much information regarding cost of clearing and other problems affecting the progress of settlers in wooded areas is contained in the bulletin already referred to *.

FERTILITY PROBLEMS OF THE GREY WOODED SOILS

Since the Grey Wooded Soils are, as a group, quite low in native fertility, maintenance of fertility is a problem which should be faced at the outset. These soils are low in organic matter, nitrogen, sulphur and phosphorus. In the future, with depletion due to cropping, other elements may become deficient. In the lighter textured soils of this group, moderately acid soils may be encountered. However, heavier textured soils are generally only slightly acid.

In improving the fertility of grey wooded soils, and especially on the sandier types, attention should first be directed to increasing their content of organic matter and nitrogen. Organic matter will improve the tilth and water holding capacity and prevent them from baking. This may be accomplished in the following ways:

1.—By retaining all crop residues on the land.

2.—By using farm manure.

3.—By using suitable rotations.

The most desirable and most efficient method is undoubtedly the third method mentioned, since a good rotation commonly implies that at least one crop should be a legume to provide additional organic matter and nitrogen. The legume crop should be properly inoculated to take full advantage of nitrogen fixation. Various arrangements of a rotation** may be adopted but a good guiding principle is to keep one-quarter to one-third of the land under a soil improving crop, such as a legume, legume-grass mixture, or grass, at all times.

In addition to the use of a rotation, it is essential that fertilizer be used on most, if not all, grey wooded soils. A proper fertilizer attachment should be used to apply the material.

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*R. A. Stutt and H. Van Vliet. An Economic Study of Land Settlement in Representative Pioneer Areas of Northern Saskatchewan. Tech. Bul. No. 52, Dept. of Agriculture, Ottawa, 1945.

**Advice on planning rotations may be obtained from the Experimental Stations at Scott and Melfort, from the University of Saskatchewan, or from the Agricultural Representative of the district.

Grain crops may be fertilized with 11-48-0* ammonium phosphate at from 30 to 50 pounds per acre. Legumes must be fertilized with a sulphur-carrying fertilizer and the recommended kinds are single superphosphate, 2-20-0 ammoniated phosphate, or 16-20-0 ammonium phosphate, at from 50 to 100 pounds per acre. A single application of a sulphur-carrying fertilizer will remain effective for as long as three years in increasing yields of both seed and forage. Results of fertilizing for seed production are rather erratic but are generally favourable on the lighter soils.

Table 13 illustrates the effect of fertilizer on forage yield and also residual effects obtained on three grey wooded soils**.

TABLE 13.—THE EFFECT OF FERTILIZER ON ALFALFA HAY YIELDS ON GREY WOODED SOILS

Increase in tons per acre

16-20-0 applied at 100 pounds per acre in spring of 1945	Loamy Fine Sand	Loam	Clay Loam
1945	1.75	0.64	0.44
1946 Residual Effect	1.29	0.38	0.50
1947 Residual Effect	—	0.55	—

Such fertilizers as 11-48-0 ammonium phosphate or triple superphosphate give little effect on the legume since they carry only small amounts of sulphur. Fertilizers like 2-20-0 ammoniated phosphate, 0-20-0 single superphosphate, 16-20-0 ammonium phosphate, and ordinary gypsum (calcium sulphate) all carry sufficient sulphur for the growth of legume crops.

As already stated, the recommended fertilizers for legumes on grey wooded soils should carry phosphorus and must carry sulphur. Whether or not nitrogen is an advantage has not yet been fully determined, but it may be noted that 16-20-0 ammonium phosphate (16% nitrogen, 20% phosphate and no potash) carries 16% nitrogen. The results obtained from this fertilizer have been as good or better than any of several used. It would seem, however, that if the legume is properly inoculated, and fixation of nitrogen is proceeding normally, then the presence of nitrogen in the fertilizer should have little advantage.

The increased growth obtained by fertilizing the alfalfa has a notable effect in building soil fertility and in improving the succeeding crop of grain. This effect is illustrated in Table 14, in which a comparison of the effect of sulphur-carrying fertilizers with those lacking sulphur is also shown. In this case, the fertilizer was applied to alfalfa plots the year previous to breaking and seeding to oats.

Where the alfalfa was treated with a sulphur-carrying fertilizer, the effect was to nearly double the yield of the succeeding crop of

*This is a convenient means of expressing the analysis of a fertilizer, e.g., 11-48-0: 11% nitrogen, 48% phosphate, no potash.

**The Effect of Fertilizers on the Yield and Composition of Alfalfa on the Podzolic Soils of Northeastern Saskatchewan. E. Schalin, M.Sc. Thesis. Soils-Department, University of Saskatchewan, 1947, and Unpublished Data of Soils Department, University of Saskatchewan.

oats in addition to greatly increasing the yield of alfalfa. Similar results have been obtained by workers in the Department of Soils, University of Alberta*, and results reported from the Dominion Experimental Station at Scott** show parallel trends.

TABLE 14.—RESIDUAL EFFECT OF FERTILIZERS, APPLIED TO ALFALFA, ON THE SUCCEEDING OAT CROP*

Fertilizer Used on Alfalfa in 1944	Rate Applied (pounds per acre)	Residual Effect on Oats (in 1945) Straw Yield tons per acre	Grain Yield bus. per acre
Single superphosphate, 0-20-0 (has sulphur)	100	1.61	46
Ammonium phosphate, 16-20-0 (has sulphur)	140	1.78	47
Triple superphosphate 0-43-0 (lacks sulphur)	70	0.74	26
Ammonium phosphate 11-48-0 (lacks sulphur)	62	0.63	25
No Fertilizer Applied	—	0.81	26

Table 14 illustrates the necessity of using the right kind of fertilizer to improve stands of alfalfa and to obtain the full benefit from this legume in a rotation. Fertilizers low in sulphur content such as 0-38-0, triple superphosphate, and 11-48-0 ammonium phosphate, are quite ineffective in producing increased yields of alfalfa, and their residual effect on a succeeding grain crop is nil on grey wooded soils.

In fertilizing old stands of alfalfa, applications are made by broadcasting the material on the field, or by drilling. In the broadcasting method, the fertilizer remains at the surface or near the surface and is only carried into the soil and to the roots of the plant by the downward movement of moisture. For this reason, better results from fertilizing by the broadcast method may be obtained by treating the field in the fall rather than in the spring. The material should be applied during the month of September or in early October.

A suggested method of using fertilizer where a rotation is practiced is as follows: (1) fertilize the grain crop following fallow or partial fallow with 30 to 50 pounds per acre of 11-48-0 ammonium phosphate; (2) fertilize the grain crop used as a nurse crop for the legume with 75 to 100 pounds per acre of 16-20-0, ammonium phosphate. The alfalfa or other legume should obtain sufficient sulphur from the heavy application of 16-20-0 so that the crop should need no further treatment during the two or three years it is growing. An advantage of this system is that the fertilizer is drilled in with the seed which is a more convenient method of application. Furthermore, it is placed in the soil where the roots of the crop may come in contact with the material.

As previously mentioned, grey wooded soils are occasionally somewhat acid in reaction and this condition may be a detrimental

*Wooded Soils and Their Management, Extension Bull., No. 21, University of Alberta, Edmonton, Alberta.

**Private Communication, Superintendent, Experimental Station, Scott, Saskatchewan.

factor in the production of legumes such as alfalfa or sweet clover. Garden vegetables such as cabbage, beets, peas and beans may also be adversely affected. Manuring the land will partly offset the harmful fertility effects of slight acidity. Liming the soil corrects acidity, but there is no convenient supply of limestone to use as a source of agricultural lime in this area. However, deposits of "bog lime" or "marl" are to be found, and if liming becomes essential on any notable acreage, this material may provide a suitable source of lime. Fortunately, very acid soils are rarely encountered and only one or two fields have been observed where the use of lime could have proved beneficial to the growth of legumes. Grains are not highly sensitive to soil acidity so little direct effect could be expected on these crops.

It has been pointed out that grey wooded soils are in general low in native fertility and that in order to improve and to maintain good yields, steps should be taken to build up and maintain the fertility of such soils. On the other hand, it may be noted that moisture conditions are favourable throughout the area where such soils occur, and that properly managed these soils are capable of producing yields equal to the better types of black soils. Where the land is of good topography, is reasonably free of stones, and of suitable texture, the grey wooded soils can be developed quite successfully for agricultural purposes if provision is made to improve their fertility at the outset.

FERTILITY PROBLEMS OF THE BLACK AND DEGRADED BLACK SOILS

A discussion of the fertility of the black soils may logically be taken to include the degraded black soils as well, since the latter are in general only slightly inferior in fertility to the black soils. Furthermore, cropping practices are practically the same on both types.

One of the first observations which should be made is that moisture conditions are almost uniformly good over the area of black and degraded black soils included in this report. The area adjacent to Lloydminster is somewhat less favoured with respect to moisture than is the remainder of the area, but moisture is nowhere such a critical problem as it is on the prairies to the south. The average yield of wheat is 19.0 bushels per acre in this area, compared to a provincial average of 15.0 bushels or less.

In spite of the better moisture conditions prevailing in this northern portion of the province, summerfallowing has become a general practice. With the exception of the slightly drier section north and east from Lloydminster to the North Saskatchewan River, summerfallowing is not practiced so much for the conservation of soil moisture as it is to control weeds. Undoubtedly, much summerfallowing could be replaced by a suitable rotation of crops, providing livestock were raised to utilize hay and coarse grains which might be grown in place of wheat. The difficulty of obtaining a water supply is a recognized handicap in the full development of a livestock industry for this region, but this difficulty may be overcome by the development of stock watering dams and dugouts.

It seems certain that the proportion of cultivated land presently being summerfallowed is greater than necessary, and that in the

long run more dependence on rotations in the cropping system is desirable. A rotational system would give assurance of the maintenance of the fertility of these soils, and what is even more important, it would provide protection against wind and water erosion. Water erosion is already a serious problem in many places and wind erosion has appeared as well, especially where clearing has been carried to the point of complete denudation.

Black soils are usually highly fertile in the virgin state. They commonly remain productive for many years under cultivation, but it should be recognized that such soils also lose fertility at a high rate by reason of the heavier crops produced. These soils will still be black in colour, and carry a large supply of humus when depletion of phosphorus has reached serious proportions. Furthermore, the good resistant structure which these soils almost invariably possess can be largely lost under cultivation without a noticeable change in colour occurring.

Lighter textured black soils require particular attention to maintenance of organic matter, and rotations including grasses and legumes are highly desirable on such soils. In addition to maintaining organic matter, the grasses and legumes will undoubtedly assist in protecting the soil from wind or water erosion.

The black soils respond well to phosphatic fertilizers. Experimental results indicate that a fertilizer such as 11-48-0 ammonium phosphate is most efficient. It should be applied with a proper drill attachment and the best response is obtained on summerfallow crops. However, there is an increasing amount of fertilizer being used on stubble crop land. This tendency is more common in the moister parts of the Province as in the eastern and north-eastern sections.

The recommended rates of application are 40 to 60 pounds of 11-48-0 ammonium phosphate for summerfallow crops. For stubble crops 16-20-0 ammonium phosphate may be used in place of 11-48-0. The 16-20-0 fertilizer has a higher proportion of nitrogen which may be of especial benefit where considerable straw and stubble have been incorporated into the soil. Suggested rates of application are 50 to 75 pounds per acre.

Table 15, given below, shows average increases obtained from 20 and 40 pound applications of 11-48-0 on black soils and also increases obtained on dark brown, degraded black and grey soils for purposes of comparison.

TABLE 15.—AVERAGE YIELD INCREASE OF FERTILIZED WHEAT ON FALLOW LAND*

Soil Zone	11-48-0 20 lbs. per acre Average Increase bus. per acre	11-48-0 40 lbs. per acre Average Increase bus. per acre
Dark Brown	4.8	6.8
Black	5.6	7.5
Degraded and Grey	4.3	6.8

*Data from Fertilizers in Saskatchewan, Bull. No. 22, University of Saskatchewan, Saskatoon, Saskatchewan.

As seen in Table 15, the response on the average has been greater on black soils than on either the dark brown or degraded types. While the recommended rate mentioned above is 40 to 60 pounds of 11-48-0 per acre, it may be noted that the smaller application of 20 pounds has given a considerable, although not the maximum increase.

Besides increasing yield the fertilizer commonly hastens maturity, which is a great advantage in a northerly area. It also helps to conserve the fertility of the soil by preventing depletion of soil phosphorus and by increasing the organic matter of the soil through providing increased residues from crops. Other advantages are control of weeds through more vigorous crop growth, control of rootrots, especially Browning rootrot, and the generally increased ability of the crop to withstand the hazards of the weather.

Depression ("Bluff") Podzols.—Throughout the degraded black and black soils scattered small areas of grey or almost white soils occur which have a soft unstable structure when moist, and a tendency to bake when dry. These soils commonly occur in moist areas as in low spots or on the margins of sloughs where a poplar "bluff" originally stood. Such soils generally produce rather poorly compared to the upland black soil. The stand of grain is often thin, and the straw and heads short. As their colour would indicate, such soils are low in organic matter and, therefore, also low in nitrogen. The first requirement to obtain satisfactory production is to add organic matter in the form of farm manure or by turning under a green crop, especially a legume. In addition, a phosphatic fertilizer is helpful but good results cannot be obtained with the commercial fertilizer alone, since one of the needs on such soils is to improve the tilth or structure so that baking when dry, or puddling when wet, will not occur.

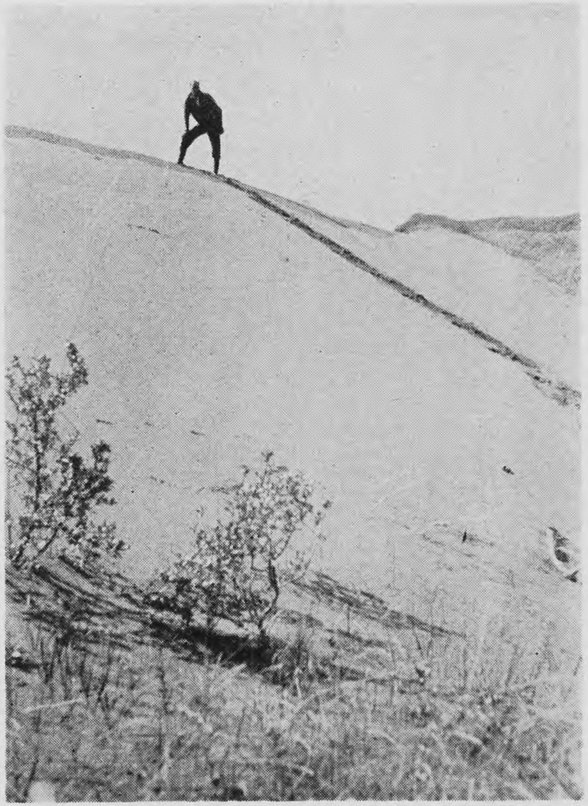
On some farms, more notably in the Waseca, Whitewood, and Oxbow soils, a fairly large percentage of the acreage is occupied by these "bluff podzols" so that their improvement is well worth accomplishing in order to raise the total productivity of the farm.

Peat Soils.—Areas of peat occur throughout the black, degraded black and grey soil areas. These soils are associated with poor drainage and hence are common to low-lying flat to depressional areas. The depth of peat may vary from a few inches to several feet, and the deeper it is the poorer the drainage, and the greater the difficulty in bringing the area under cultivation. Peaty areas require drainage before cultivation is fully successful. Shallow peats of four to six inches depth can often be brought into cultivation directly and cropped to coarse grains. This is especially true if some mineral soil can be brought up to the surface to mix in with the peat. Sufficient improvement of drainage in such areas can often be accomplished by clearing natural drainage channels and by opening shallow ditches. Road construction can assist drainage by supplying run-off channels.

Deeper peats are best handled by improving the drainage and then pasturing for several years. The pasturing animals manure and pack the soil which, along with drainage, tends to hasten decomposition of the peat. Pasture and hay crops are more suitable than coarse grain crops, at least in the early development of deep peats. Wheat

PLATE 31

Wind erosion spreading across a cultivated field in north-eastern Saskatchewan. There is no trash cover to protect the surface.



This dune is a result of careless destruction of natural vegetation.

is generally unsuitable as a crop on peat because of the frost hazard.

Peat should not be burned. Burning destroys peat almost completely since it is largely organic in nature. This means a loss of valuable organic materials and the nitrogen which it contains. Furthermore, destruction of the peat surface may expose a mineral soil of low productivity which may be a great deal more difficult to improve than the peat itself. It is not uncommon to find that the mineral soil underlying the peat is a tight clay which is very difficult to handle under cultivation.

Where peat land has been burned over, the first requirement is to return organic matter to the soil. In addition, the use of phosphatic fertilizer is desirable.

In handling peat land under cultivation it is important that the seed bed be well packed. Peat tends to be spongy, and will often dry out quickly to a depth of several inches unless it is packed firmly.

Peats will quite often respond to manuring especially when in the less decomposed state. The manure promotes the processes of decomposition which release nutrient elements for the use of the plant. Commercial fertilizers such as 16-20-0 ammonium phosphate have given good responses as well. None of the peats so far brought under cultivation appear to be acid enough to require liming.

SOIL EROSION AND ITS CONTROL

It is impossible to over-emphasize the need for maintaining a constant guard against the destructive effects of soil erosion. There is no farm anywhere in the whole of Saskatchewan which is entirely safe from the danger of erosion by either wind or water. It is a fallacy to believe that soil drifting cannot be serious in areas where there are, or have been, plenty of trees. The better moisture conditions of such areas as compared to the prairies may enable the farmer the more readily to obtain a protective cover of vegetation, and to maintain the organic matter of the soil at a satisfactory level, but recent years have seen the advent of serious wind erosion in areas which less than twenty years ago had only a few clearings in the forest, while water erosion has now become a formidable problem on many farms of the north.

Erosion, whether by wind or water, attacks the fertile surface of the soil. Bare, unprotected land is, therefore, most susceptible. The summerfallow field is the first land to suffer because cultivation is designed to destroy all weeds, and at the same time may pulverize the soil so that it has little resistance to erosion. The effects of erosion are destructive to both the chemical and physical characteristics of the soil. The sifting by the wind and washing by the water tends to remove clay and humus, and along with these important constituents there is a loss of valuable nutrient elements. For instance, the source of the important element nitrogen is in the humus of the soil, and much of the phosphorus is contained in the clay. Furthermore, continued erosion results in lighter soils because it is the sand which remains behind as the texture becomes coarser. This not only results in lowered fertility, but also in lowered water holding capacity and consequently a lowered drought resistance. This loss of clay and

PLATE 32

Rill erosion on rolling topography. Note absence of erosion on uncultivated land.

Gully erosion on rolling topography. Deep gullies may expose the stony subsoil and also prevent the passage of heavy farm machinery.

organic matter also results in a poorer soil structure so that the resistance to further wind erosion is decreased.

The methods of preventing erosion are fully outlined in the "Guide to Farm Practice in Saskatchewan"*. It is a subject with which every farmer should have some familiarity, since most of the damage from erosion which has occurred could have been avoided if proper steps towards control had been taken in time.

Maintaining the surface soil in such a condition as to resist erosion depends upon maintaining a crop cover or a surface cover of stubble or other plant residues, together with a cloddy-granular surface soil where the latter is possible. Sandy soils generally do not form resistant clods, so become highly susceptible to wind erosion when left bare to the elements. Water erosion is more likely to affect sloping heavy soils. Damage increases with the length and steepness of the slope once water erosion begins.

Since summerfallowing to conserve moisture is not so necessary in the area covered in this Report as it is on the prairies to the south, erosion should not become such a serious problem, providing the summerfallow practice is replaced by suitable soil conserving rotations.

AGRICULTURAL SUITABILITY OF SOIL ASSOCIATIONS

A tentative grouping of the soils was given in Soil Survey Report No. 12 covering the area of Saskatchewan lying south of the present area. This grouping was based on a numerical rating, which reflected suitability for grain production, especially wheat.** The wheat crop is by far the most important crop in the prairie area, and is likely to remain so. In the present area, while wheat is the dominant crop, the acreage of coarse grains has a much greater comparative significance. Furthermore, a greater diversity of crops is possible throughout this northern area including forage crops, legume seed crops, rape seed, peas, and others. Hence, it is necessary to indicate comparative suitability for other crops as well as wheat. These recommendations are to be considered as tentative because of the brief agricultural history of many of the soils. Changing methods of management and cultivation may greatly affect the future productivity of any of the soils discussed herein.

In the following table, the soil associations have been arranged according to their general suitability for agriculture, beginning with the best soils. The numerical index is given for each textural type in the Association. The arrangement and the numerical index are based on the better arable conditions. Soils which are more stony than average or of rougher topography are given lower ratings accordingly. Soils with higher numerical indexes may be considered as the more productive, especially respecting suitability for grain growing.

The soils may be arranged in the following groups according to their index rating:

Excellent soils..76 and above

*"Guide to Farm Practices in Saskatchewan." Obtainable from Department of Extension, University of Saskatchewan, Saskatoon; from Dominion Experimental Stations; or from Department of Agriculture, Regina.

**A Method of Obtaining a Comparative Rating of Saskatchewan Soils. J. Mitchell, Scientific Agriculture, 20:5, 1940.

Good soils .... 61 to 75.
Fair soils .... 48 to 60.
Poor soils .... 32 to 47.
Very poor soils .... below 32.

TABLE 16.—COMPARATIVE RATINGS AND AGRICULTURAL SUITABILITY OF SOIL ASSOCIATIONS

Soil Association	Comparative Index No.	Crop Adaptability and Special Problems
Melfort		
Silty Clay and Silty Clay Loam	87	Well adapted to wheat, coarse grains and forage crops. Peas and rape grown successfully. Water erosion often serious.
Silt Loam	74	
Loam	71	
Kamsack		
Silty Clay	81	Well adapted to wheat, coarse grains and forage crops. Water erosion serious in places.
Clay	79	
Silty Clay Loam	75	
Clay Loam	71	
Silt Loam	68	
Loam	65	
Tisdale		
Clay	78	Good to fair adaptation to wheat. Well adapted to coarse grain and forage crops production. Malting barley successfully grown. Water erosion serious in limited areas.
Silty Clay Loam	78	
Silt Loam	70	
Clay Loam	70	
Heavy Clay	64	
Canora		
Silty Clay Loam	77	Wheat, coarse grains and forage crops all quite successful. Water erosion serious on sloping land. Wind erosion a danger especially on lighter textures.
Clay Loam	70	
Silt Loam	68	
Loam	63	
Light Loam	54	
Blaine Lake		
Clay	79	Wheat and coarse grains, good to fair, forage crops fair. Wind erosion may be serious. Water erosion occurs on sloping land.
Silty Clay Loam	70	
Clay Loam	68	
Silt Loam	60	
Loam	59	
Light Loam	55	
Lloydminster		
Loam	68	Fair wheat soils, frost hazard fairly high; good for coarse grains and forage crops.
Light Loam	61	
Arborfield		
Silty Clay	68	Fair wheat soils. Frost hazard fairly high; good for coarse grains and forage crops. Water erosion may become serious on sloping land.
Silty Clay Loam	68	
Clay	63	
Clay Loam	61	
Heavy Clay	60	
Meadow Lake		
Clay Loam	77	Good to fair wheat soils, frost hazard fairly high; good for coarse grains and forage crops.
Silty Clay Loam	73	
Loam	68	
Clay	62	

Soil Association	Comparative Index No.	Crop Adaptability and Special Problems
Makwa		
Clay Loam	73	Good to fair wheat soils, fairly high frost hazard. Good for coarse grains and forage crops. Wind erosion may become serious on lighter textures.
Loam	64	
Light Loam	56	
Beaver River		
Clay Loam	70	Good to fair wheat soils, fairly high frost hazard. Good for coarse grains and forage crops.
Loam	60	
Kelsey		
Silty Clay Loam	75	Good wheat soils, frost hazard moderately high. Good for coarse grains and forage crops.
Clay Loam	70	
Loam	62	
Nipawin		
Clay	76	Good wheat soils, good for coarse grains and forage crops.
Clay Loam	69	
Loam	63	
Weirdale		Ratings and adaptations similar to Canora.
Oxbow		
Clay Loam	69	Fair to good wheat soils, fair to good for coarse grains, fair for forage crops. Wind erosion may be serious on lighter textures, water erosion serious on slopes.
Loam	61	
Light Loam	49	
Pelly		
Clay Loam	72	Fair to good wheat soils, frost hazard fairly high. Good for coarse grains and forage crops.
Loam	63	
Whitewood		
Clay Loam	65	Fair wheat soils, fair for coarse grains, fair to good for forage crops. Moderately low in organic matter and general fertility.
Loam	51	
Light Loam	44	
Waseca		
Clay Loam	63	Fair wheat soils. Fairly high frost hazard, fair to good for coarse grains and fair for forage crops.
Loam	57	
Light Loam	54	
Onion Lake		
Heavy Clay	63	Fair wheat soils, fairly high frost hazard, fair for coarse grains and forage crops.
Clay	55	
Clay Loam	49	
Loam	49	
Paddockwood		Ratings and adaptations similar to Yorkton and Canora.
Shellbrook		
Loam	63	Fair for wheat and coarse grains, fair to good for forage crops. Rape has been grown successfully. Wind erosion may be serious.
Light Loam	56	
Very Fine Sandy Loam	50	
Fine Sandy Loam	41	

Soil Association	Comparative Index No.	Crop Adaptability and Special Problems
Garrick		
Silty Clay Loam	60	Fair wheat soils, fair to good for coarse grains and forage crops. Alfalfa seed has been produced successfully. Moderately low in organic matter and general fertility.
Clay Loam	57	
Loam	48	
Dorintosh		
Clay Loam	61	Fair for wheat, fairly high frost hazard, fair for coarse grains, fair to good for forage. Low in organic matter and general fertility.
Clay	56	
Loam	53	
Meota		
Light Loam	53	Prevention of wind erosion of first importance. Provision should be made for maintaining or increasing organic matter. Fair soils for wheat, coarse grains and forage crops.
Very Fine Sandy Loam	51	
Fine Sandy Loam	43	
Horsehead		
Clay Loam	59	Provision for increasing organic matter and general fertility important. Fair wheat soils, frost hazard fairly high. Fair for coarse grains and forage. Alfalfa seed has been produced successfully.
Loam	49	
Light Loam	42	
Whitefox		
Light Loam	56	Prevention of wind erosion and maintenance of organic matter of first importance, fair for wheat and coarse grains; fair to good for forage crops.
Very Fine Sandy Loam	50	
Fine Sandy Loam	41	
Carrot River		
Light Loam	56	Prevention of wind erosion and maintenance of organic matter of first importance. Fair for wheat and coarse grains; fair to good for forage crops.
Very Fine Sandy Loam	50	
Fine Sandy Loam	41	
Loon River		
Clay Loam	52	Provision for increasing organic matter and general fertility important. Poor to fair wheat soils, frost hazard fairly high; poor to fair for coarse grains; fair for forage crops. Alfalfa seed has been produced successfully.
Loam	43	
Light Loam	37	
Waitville		
Clay Loam	50	Provision for increasing organic matter and general fertility important. Poor to fair wheat soils, frost hazard fairly high; poor to fair for coarse grains and forage crops. Alfalfa seed has been produced successfully.
Loam	42	
Light Loam	38	

Soil Association	Comparative Index No.	Crop Adaptability and Special Problems
La Corne		
Loam	57	Prevention of wind erosion and provision for increasing organic matter important. Poor to fair for wheat and coarse grains, fair to good for forage crops. Alfalfa seed has been produced successfully.
Light Loam	50	
Very Fine Sandy Loam	44	
Fine Sandy Loam	36	
Smeaton		
Loam	48	Prevention of wind erosion and provision for increasing organic matter important. Poor to fair for wheat and coarse grains, fair to good for forage crops. Alfalfa seed has been produced successfully.
Clay Loam	44	
Light Loam	40	
Very Fine Sandy Loam	37	
Fine Sandy Loam	34	
Whitesand		
Light Loam	47	Prevention of erosion and maintenance of organic matter important. Poor for wheat and poor to fair for coarse grains; fair to good for forage crops.
Gravelly Loam	47	
Sandy Loam	31	
Glenbush **Bodmin** **Pine** **Sylvania**		These soils are of low productivity. The sandy members are highly susceptible to wind erosion. In some cases they have been successfully used for forage crops (pasture and hay) and also for legume seed production, particularly alfalfa. They are not to be considered as suitable for grain farming.

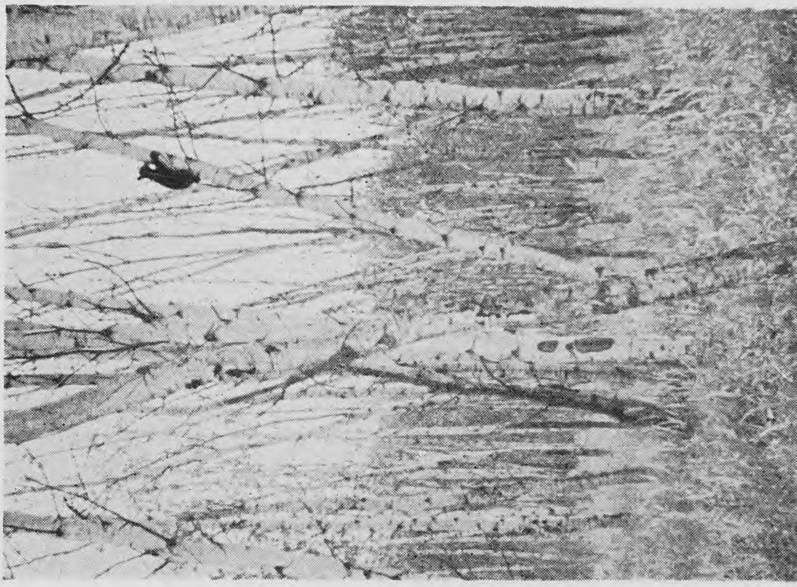
Land Resources and Their Conservation

The total area included in this survey is about 6,323,000 acres, of which some 3,600,000 acres were listed as occupied land in 1946. Reserved for forest reserves and parks within the area are some two million acres of land and a portion of the Prince Albert National Park extends into the area. Thus, three main types of land utilization are demonstrated, each with its own problems of conservation and its own peculiar benefits to the individual, the community and the nation. These are: the Agricultural use for both crop and pasture; the Forestry use in which the tree becomes the main crop produced by the soil; and the Recreational use in which the land with its forests, streams, lakes, and wild life is preserved in the natural state for the enjoyment of the public.

Agricultural Land.—The problems of fertility and erosion of cultivated lands have already been discussed in previous sections. This section, will, therefore, merely endeavour to emphasize that careful conservation of the soil is just as imperative in this area as it is anywhere on the plains to the south. Since moisture conditions are better than on the plains, it is possible to reach a more intensive scale of agricultural production and the income per acre of cultivated land

PLATE 33

Fires destroy the trees, and the great benefits of the forest are lost. Most fires are caused by human carelessness.



Green forests protect wild-life and soil. The trees provide fuel, shelter and a source of income. Note the bear cub.

should consequently be better. This desirable end will not be accomplished unless the fertility of the soil is maintained or improved. Even the poorer Grey Wooded soils are capable of production nearly comparable to that obtained on Black soils if the necessary steps are taken to improve their fertility.

One of the notable differences between this area and the open plains is that the vacant lands are bushland rather than grassland. This is a point not always appreciated by the settlers, a majority of whom migrated to the area as a result of the drought period in the thirties which drove them from their prairie farms. To many of these people, the forest was an enemy to be destroyed so that the land might be broken. This is a reaction which can hardly be criticized but it can be pointed out that it is possible to farm in a forest area, and at the same time find it well worthwhile to protect and conserve the green forest. The relationships between farm and adjacent forest are not fully appreciated until the trees are gone. In the first place, trees may supply a source of income, especially in the pioneer areas. It may be that some form of farm-forestry scheme could be developed in which forest land reasonably near the farm property could be leased for the purpose of harvesting the trees, just as ranch lands are leased in the south for grazing purposes. This is a modification of the farm woodlot of eastern Canada, and similar to farm-forest practices of many European countries.

Some farm districts which were literally cleared from the forests no longer contain a supply of firewood, poles and fenceposts since the forest is now beyond the edge of settlement. There are other results following the total destruction of the forest. The sheltering effect of the trees from the wind and sun are lost, and some of the area has now the aspect of the open prairie. The number of game birds, songsters, and animal life is greatly diminished by the destruction of their natural habitat. Insect pests may greatly increase. All in all, there seem to be so many good reasons for preserving some of the native forest vegetation in our agricultural areas that it is hard to justify the excessive amount of clearing which has occurred. Fortunately, the re-establishment of trees in this area is not so difficult as is the establishment of shelter belts on the prairies.

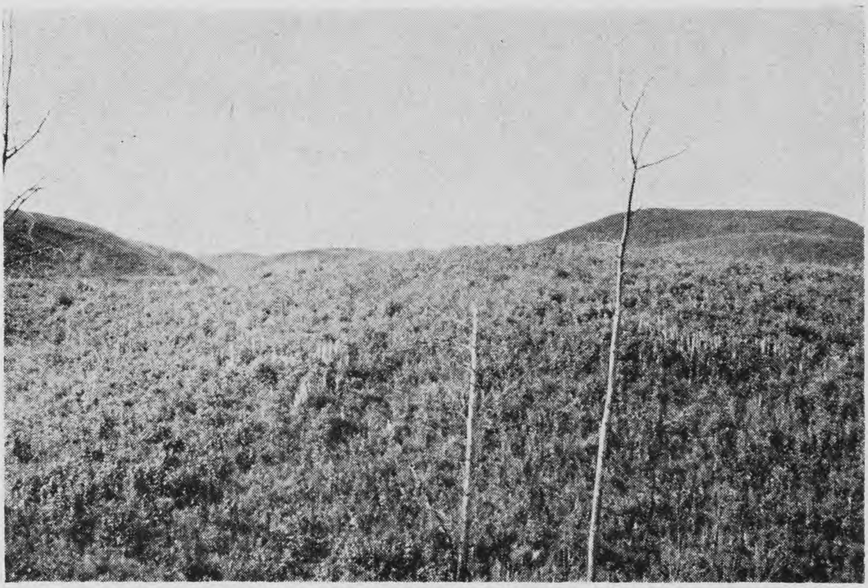
Forest Land.—There are over two million acres of land reserved for forestry within this surveyed area. Beyond a few traverses where roads were available, no attempt was made at classifying the soils in Forest Reserves. However, there is enough knowledge of the land within these Reserves so that it may be stated quite definitely that little or none of it is suitable for agricultural use. The best crop for such non-arable land is the native trees, just as the prairie grass is the best crop for much of the non-arable land to the south.

Since trees grow rather slowly, it is difficult for the layman to visualize the possibility of harvesting a crop every season as is done in the case of agricultural crops. However, this is possible, and in fact is a recommended forestry practice. It has been suggested* by a Forestry Commission that the forests of Saskatchewan might produce an average sustained yield of one-quarter cord per acre per year.

*Report of the Saskatchewan Royal Commission on Forestry, Province of Saskatchewan, Regina, Saskatchewan, 1947.

PLATE 34

Repeated burning has destroyed the forest cover and exposed the soil to the elements.



Scrubby new growth is covering the soil bared by fires, but in this state the area is of no value either for agriculture or forestry.

This amount might be capable of increase by using efficient and proper forest management. This estimated production is made the basis for suggestions regarding the possibility of establishing Forestry Farms in this Province. The crop yield in this case would be represented in cords of wood, or board feet of saw logs instead of bushels of grain or tons of hay per acre. The main point to be realized is that the forest is capable of producing and continuing to produce a considerable income to the people of this Province, and as such is well worth an effort at conservation. By far the greatest destroyer of forests is fire. Fire prevention is, therefore, the keynote in forest conservation.

The annual reports of the Provincial Department of Natural Resources* provide enlightening statistics in connection with forest production and loss by forest fires. For instance, more than half the commercial forest area has been burned since the year 1910. The cost of fighting fires since 1930 is estimated at four million dollars. And by far the larger number of fires are attributed to the carelessness of human beings!

Turning to the income from the forest, we find that in the year 1945-46, the total value of forest products was over seven million dollars, a very creditable showing from a resource that has suffered so greatly from man's carelessness and neglect.

The value of green forest is not only in its trees. The green trees are a protective covering for the soil and a habitat for the furred and feathered creatures who themselves may produce income for man, give him pleasure, or protect his crops from pests.

There are other benefits to be derived from the protective covering of green trees. Water levels are probably better maintained than on a bare watershed and the run-off is more uniform with less silt and clay in the streams. Silting of streams increases with increasing soil erosion, a condition which may readily follow the denudation of forest cover from steep hillsides.

Conservation of land resources includes the conservation of forest on lands more suitable for producing a crop of trees than a crop of grain or hay, but a long range view must be cultivated in order that a full appreciation of the value of the forest may be attained.

Recreational Use.—The use of the land for the purposes of recreation is increasingly important, and both Provincial and Dominion Governments have been wise in setting aside Parks in suitable areas throughout the Province, but particularly in the northern districts.

Each year a larger proportion of the population takes advantage of these park facilities, and many tourists from outside the Province and the Dominion find their way to them. It is difficult to assess an actual benefit derived in terms of dollars and cents, but that some benefit does accrue because of visiting tourists is unquestionable. The greater benefit is probably in the satisfaction and enjoyment of our own people through providing a holiday in nearby and pleasant surroundings.

*The Natural Resources of Saskatchewan, 1947, Department of Natural Resources and Industrial Development, Regina, Sask.

The educational value which these park areas provide when properly managed should not be overlooked. The opportunity they offer for the preservation of the native flora and fauna for the study of future generations, and the example of conservation they provide for the present one are indeed worthy contributions to our cultural life and heritage.

Geology and its Relationship to Soils in Saskatchewan

By F. H. EDMUNDS

Department of Geology, University of Saskatchewan

THIS SECTION is a revision of the geology section given in Saskatchewan Soil Survey Report No. 12 (1944 and 1947) and special reference is made to the geology of the present map area.

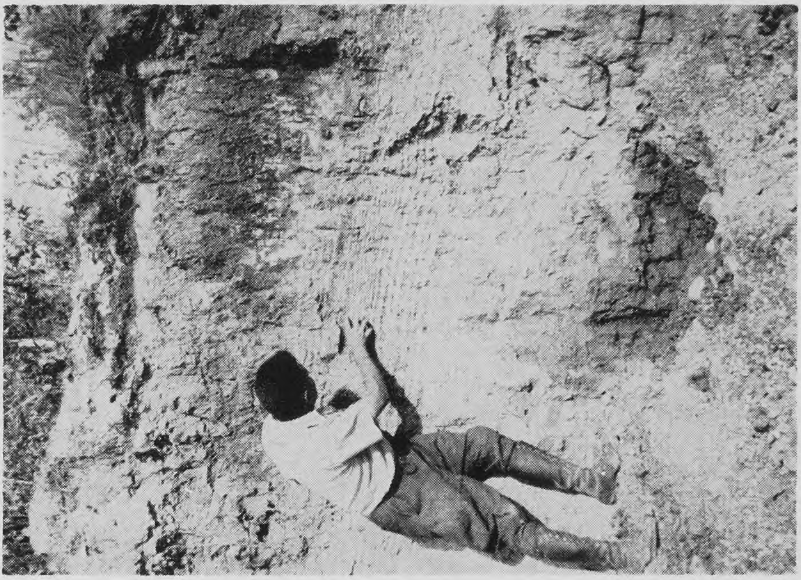
In Saskatchewan the mineral constituents of the soil are geologic deposits of Recent and Pleistocene Age. Recent and Pleistocene deposits have been derived from older formations and thus there is a relationship between the soils and the rocks underlying the country. In a few localities the soil has been formed directly from the weathered material of the underlying rocks. These materials are called **Residual.** More commonly the soil has been derived from rock debris which has been transported by ice, water or wind in recent geologic times. These materials are called **Transported.** Often the material has been transported long distances; thus much of the mineral matter on the Saskatchewan prairies has been brought by ice from the north and the characteristics of the soil have been influenced by the type of rock found in the north.

The soil is considered by the geologist as a rock—a soft, unconsolidated rock, it is true, but the term "rock" does not necessarily imply hardness. The soil itself is of very recent origin, but is derived from rocks of varying age, some of which contain small quantities of the important plant foods, such as phosphorus and potassium. These plant foods can only be made available for use when the rock becomes broken down by the mechanical and chemical process known as "weathering."* In addition to these processes, biological factors are active in soil formation.

The breaking down of rocks and the transportation of sediments and salts by rivers, followed by the deposition of the sediments, are geological processes that have been effectively reducing land areas since the earliest geological times. Had there been no earth movements causing gentle raising of certain areas and more violent mountain building in others, the land surface would have been reduced to a monotonous sea level plain ages ago. While these processes of weathering and transportation, of deposition, and of earth movement are active at the present day, they make little mental impression because the rate of their operation is slow compared with the life span of man. But when we study the rocks and their relationships to one another, we are able to look back into the geological past and see the

*Textbooks of Physical Geology which discuss weathering processes in detail and for use in Canada, "Elementary Geology for Canada," by E. S. Moore, $3.50, published by Dent and Company, Toronto, is recommended. Others are equally useful—they include: "Outlines of Geology" (Part I—Physical Geology) by Longwell, Knof and Flint; "Physical and Historical Geology," by Cleland; "Elements of Engineering Geology," by Rees and Watson; "Rocks, Rock-Weathering and Soils," by Merrill.

PLATE 35



Varved glacial lake silty clay, overlying boulder clay. Both deposits are highly calcareous.

Dark grey, compact boulder clay with relatively low content of lime carbonate. (Lloydminster area.)

results of these processes and the immense changes that they have brought about. By piecing together the information collected from here and there we are able to obtain a picture of the earth's history which is fairly clear in places, but vague in others. Rocks ranging in age from Pre-Cambrian to Recent are distributed over the earth's surface, contributing to the soils, providing valuable minerals and fuels and causing the diversifications of topography.

While for much of geological time the region now known as Saskatchewan has been dry land, it has on several occasions been submerged. Deposits of limestones, sands and muds formed at times of submergence contribute to the soils. The accumulation and spread of ice over the area in fairly recent geological times resulted in the formation of unconsolidated materials known as "glacial drift," and these glacial deposits are of the utmost importance as soil-forming materials, and their topographic features have an important bearing upon agriculture. Since glaciation was an event of paramount importance to the Canadian West, it will be discussed in more detail than the other phases of the Geological History.

Rocks.—Rocks are of three kinds: (a) Sedimentary, (b) Igneous, and (c) Metamorphic.

(a) Those laid down mostly under water and occurring in beds piled layer upon layer are known as sedimentary or stratified rocks. (An individual bed of rock is known as a stratum.) Such beds are usually formed from mud, silt, sand, gravel or lime materials, which on hardening produce the types known as shales, siltstones, sandstones, conglomerates, and limestones, respectively. These rocks often contain remains of plants or animals which lived at the time of deposition and became buried in the sediment. These remains are known as fossils, and are of great importance in determining the relative age of the sediments; they also give a clue to the climatic and other physical conditions of the times. Sediments that have been deposited by rivers on their flood plains are known as alluvial. Lake-bed material is referred to as lacustrine, while the deposits of the sea are marine. Deltaic deposits are built out by some rivers into seas or lakes, and these are transitional between alluvial and marine or alluvial and lacustrine. In Saskatchewan, sedimentary beds are nearly horizontal, the most recently formed beds being on top and the oldest at the bottom. In many parts of the world, however, particularly in mountainous regions, the beds may be tilted, folded, or even overturned.

(b) Those rocks which are the result of the solidification of molten material are known as igneous. Solidification may take place near the surface of the ground, resulting in volcanic types, or at some distance below the surface in veins or large masses, as in the case of granite. The vein type of igneous intrusion is in some cases represented by important ore deposits.* In Saskatchewan the igneous rocks are found in the Pre-Cambrian country of the north.

(c) Rocks which have been subjected to intense heat and pressure are altered and give rise to what are known as metamorphic rocks. Recrystalization of the mineral matter frequently takes place

*An ore is a mineral deposit that can be mined profitably. A quartz vein would be considered an ore if only a minute quantity of gold were present, provided that the rock could be mined and the gold extracted in such a manner that the operation showed a profit.

and banded textures are produced. Gneisses and schists of this group are common varieties found in the Pre-Cambrian area.

Granites and other igneous rocks, also metamorphic varieties, are found as boulders in the prairie area, where their presence is due to the transporting action of ice in glacial times.

SUB-SURFACE GEOLOGY

The geological history of an area is recorded in the rocks which underlie the area. The principal events of the past have been floodings by sea, uplifting from the sea and erosion. Along with these there are variations in climate and in the types of plants and animals that have inhabited the area. These events are recorded in the rocks that underlie the area. It is true that a study of the rocks can only give a broad picture of the past, since there are great gaps in the history and much detail is obscure. In order to obtain a general idea of the geology of an area such as that of the northern prairie belt it is necessary to consider the geology of a larger area and also to have information from any borings and deep wells either in the area itself or in adjacent areas.

A complete list of the rocks underlying Saskatchewan is given in Table 17. This table is adapted from the report "The Geology of Southern Saskatchewan," published by the Canadian Geological Survey (Memoir 176, 1935). Additions and alterations that have been made to the original table are the result of new information obtained from the drilling of deep wells since 1940. Many of the terms used in the table are technical ones that have been adopted for convenience of classifying and filing geological information. Geological time is divided into eras, eras into periods, and periods into epochs. The terms used in the table for these divisions and subdivisions are world-wide in their application. The rocks deposited during an epoch are split up into mappable units called formations, and the name given to a formation is often the place name of the locality where the rocks of that formation are well developed. The estimates of time represented by the geological periods are included more from the desire to indicate the great length and relative time values of the period than to give exact figures.

NOTES ON GEOLOGICAL ERAS AND PERIODS

Eras and Periods.—The large divisions of geological time called eras have been given names which refer to the broad feature of the life of the times. Pre-Cambrian times are often referred to as the **Cryptozoic eon,** meaning hidden life. The Pre-Cambrian rocks have so few fossils that little is known of the life of those times.

Palaeozoic means ancient life. The periods of the Palaeozoic, with the exception of the **Carboniferous,** were given names derived from places where the rocks of the period are well represented. Cambria is the name for Wales. The Ordovices and Silures were the names given by the Romans to British tribes inhabiting North and Central Wales respectively. Devonshire is a county in south-west England. Perm is a Province west of the Urals in Russia. **Carboniferous** refers to the extensive development of coal in the rocks of that period but place names are given to major subdivisions of the period; as on this continent, **Mississipian,** and **Pennsylvanian.**

Fossils are abundant in the Palaeozoic rocks but very few of the animals they represent were like animals living today. An extinct group of marine insect-like animals known as Trilobites were common and must have been a dominant group of sea animals until Devonian times. The Devonian is known as the Age of the Fishes. Fish were then the predominant sea animals. Corals, crinoids (sea lilies) and brachiopods also abounded in the seas of the Palaeozoic. Evidence of the first

land plants is found in Silurian rocks, of the first land animals in the Devonian. By the time of the Permian, land animals were plentiful and that period is known as the "Age of the Amphibians."

Mesozoic means middle life. The periods are—**Triassic,** a name referring to the three-fold division of rocks in the type locality of Northern Germany, **Jurassic** called after the Jura region of France, and **Cretaceous** from **Creta,** the Latin word for chalk. Cretaceous rocks are not all chalk but it so happens that where the rocks of the period were first described, in south and eastern England and northern France, they consist largely of chalk. There are no chalk beds in the Cretaceous rocks of Western Canada.

The **Mesozoic** era is also called the "Age of the Reptiles" and it is a time when reptiles were among the inhabitants of sea, land and air. On land the most abundant reptiles were the Dinosaurs (Terrible Reptiles). The first record of flowering plants comes from rocks of Cretaceous age and until this or subsequent times there were no grasses and the plains areas of the earth must have been largely devoid of vegetation and of animal life. In the sea, fish were abundant; Pelecypods (clams) and an extinct group of Cephalopods known as the ammonites were prolific.

The **Cenozoic** or the age of recent life is also called the "Age of Mammals." The spread of flowering plants and grasses paved the way for the spread of the mammals which replaced the reptiles as the dominant land animals. In the sea, fish still persist, and clams and snails are also abundant. The Epoch names for this era refer to the life in a general way, for example **Eocene** means dawn of recent life. The Pleistocene was the time of the ice age in North America. The earliest indications of man on the earth are found in rocks of Pliocene age.

Considerable uncertainty exists with regard to the time when man first inhabited the plains. It seems likely, however, that the country was inhabited shortly after the disappearance of the ice sheets. Vast numbers of flint implements such as scrapers and arrowheads are scattered on the prairies. The easiest places in which they are to be found are where the sandy land has drifted and blow-outs have been left. It is remarkable that very few of the sand blow-outs that have been searched have failed to yield some implements or pieces of pottery and it seems probable that there are few if any areas in which specimens cannot be found. A number of diligent collectors have thousands of implements and it is hoped some day that some of these collections can be housed in a Provincial museum. In order that a record of early inhabitants of Saskatchewan can be worked out, it is necessary that material from as many localities as possible be available for study. A specimen itself is of little value for scientific or historical study unless the location and type of country or material in which it was found, are recorded. There are a great number of beautifully mounted collections of arrowheads but they have little scientific value because there is no information of the exact location and often no knowledge of the approximate region of the find. Even when kept in a personal collection, the location as well as the specimen should be preserved for it may be of considerable value in the future. It is to be hoped that many of the private collections will eventually find their way to Canadian museums.

The geological sketch map on page 210 shows the distribution of the bedrock formations. The bedrock is, for the most part, obscured by the mantle of surface soil and drift material and there are very few outcrops*. The boundaries between formations cannot be accurately placed but their general position is known by observation and mapping of the existing outcrops and by the record of formations encountered in drilling. In the diagrammatic section (Figure 9) the vertical relationship of the formations is shown for a north to south line. The section also shows the regional structure which is that of a basin with the strata dipping towards the south-west. The dip shown in the diagram is highly exaggerated and actually is about ten feet per mile.

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*Outcrop is the term used for an exposure of bedrock at the surface. Outcrops are most commonly found on steep valley sides, and on hill and mountain sides. There are extensive outcrops in northern Saskatchewan where the continental ice sheet carried away the weathered surface material that overlay the hard Pre-Cambrian rocks. There are numerous outcrops in the uplands of the south such as the Cypress Hills but on the prairies there are only occasional ones.

To explain the presence of the beds that overlie the Pre-Cambrian rocks, it is necessary to consider that the basin has been slightly unstable, subject to occasional sinkings and less pronounced upliftings. The following description of the sequence of events is necessarily brief, and for its elucidation frequent reference to the table, map and section should be made.

PRE-CAMBRIAN

The Saskatchewan northland, where Pre-Cambrian rocks lie at the surface, is a region of bush, lakes, hard rock ridges, and rivers. A small part of the bedrock present in this large tract consists of very old sediments and surface volcanic flows, now largely metamorphosed to schists and gneisses, and occurring as widely separated remnants. Of greater extent are the areas underlain by igneous rocks, particularly granites which have been altered by great pressure to the metamorphic type—granite gneiss. The rocks as a whole show that great earth disturbances took place and that mountains, now removed by erosion, were in existence in Pre-Cambrian times.

Related to the igneous action there are metalliferous veins and bodies containing such metals as copper, zinc, lead, and gold. The Flin Flon copper-zinc ores in the eastern Pre-Cambrian area, and gold ores in the Goldfields area in the west are examples of these metalliferous deposits.

The soil directly overlying the Pre-Cambrian rocks is often very shallow and frequently of sandy texture. The soils consist chiefly of podzolic and bog (peat) types. It is not known if any extensive soil belts exist. Gardens at the missions and posts show the excellent results of labour and perseverance, but the country has little agricultural potentiality.

Most of the stones and boulders found on the prairies are of Pre-Cambrian rocks which were carried from the north by ice in glacial times. As well as the stones and boulders, the glacial deposits contain much fine sand and silty rock flour which is Pre-Cambrian rock ground up by the ice action. This fresh mineral matter has largely contributed to the fertility of the prairie soils by the addition of potash and phosphorus.

PALAEOZOIC

The Palaeozoic rocks of Saskatchewan are mostly limestones and shales. They are found at the surface in a belt fringing the Pre-Cambrian area of the north and have been encountered in deep wells drilled on the prairies. In Manitoba and northern Saskatchewan only Palaeozoic rocks of Ordovician, Silurian and Devonian age have been recognized, but beneath southern Saskatchewan, in what is known as the Moose Jaw basin, deep drilling has disclosed the presence of Carboniferous rocks as well.

In contrast to the Pre-Cambrian rocks, the limestones have not been altered or strongly folded by any intense pressure or severe earth movements, nor have they been affected by igneous action. The major movement in this area in Palaeozoic time was gentle sinking and uplifting. Fossils of marine shellfish, corals and sponges are found in the limestones and indicate clearly that the rocks were formed

as deposits at a time when the area lay below the sea. Beds of gypsum* and salt, which are occasionally inter-bedded with the limestones, show that temporarily land-locked bays or lagoon lakes came into being, where vigorous evaporation of the sea water caused the precipitation of the gypsum and salt.

Salt beds have been discovered by drilling in many parts of the province. At Unity they are at a depth of 3,692 feet and salt is being produced by the Prairie Salt Co. In addition to common salt, there are interbedded potash deposits. Other localities at which salt has been discovered in beds of Palaeozoic age are: Battleford, Maidstone, Davidson, Simpson, Radville.

The limestones are cream, pink or light grey in colour. Ordovician limestone is quarried at Tyndall, Manitoba, and is one of the most common building stones used in Saskatchewan. Reef limestones, made up, in part of the remains of corals and other organisms, have been discovered recently in Alberta. At Leduc, Redwater and Stettler these reefs contain important deposits of oil. They are of Devonian age and there is reason to expect similar reef conditions in the Devonian and other Palaeozoic rocks of parts of Saskatchewan. Boulders of limestone are prevalent in the glacial drift of some parts of the Province, the boulders having been carried from the limestone outcrop belt of the north by ice. In a few places these boulders have been used for building purposes; the beautiful buildings on the University campus at Saskatoon are a notable example.

The areas in Saskatchewan where the surface is directly underlain by limestone are remote and have not been explored or exploited so that little is known about the soils overlying them. The influence of the Palaeozoic limestones upon Saskatchewan soils is indirect. Much of the high calcium and magnesium content of the glacial drift is due to the limestone which was picked up and ground by the ice.

MESOZOIC

Rocks of the Mesozoic era are divided into the three systems— Triassic, Jurassic and Cretaceous. All these systems are represented in the prairie region but only the Cretaceous is found at the surface. The other two are deeply buried and undelie only the southern parts of Saskatchewan.

CRETACEOUS

Cretaceous rocks are widespread at the surface and they also underlie the country. For the most part they are marine shales deposited in an extensive sea which stretched from the Arctic to the Gulf of Mexico. Within the system, however, there are sands of shoreline and deltaic origin and also sands, clays, and coal seams of alluvial plains and swamps. These Cretaceous rocks have profoundly influenced the soils of the province, and are responsible for their general heavy-textured character. Shale forms the principal ingredient of the glacial drift, and it is the glacial drift which is the parent material of most of our soils.

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*Calcium sulphate in a massive form.

TABLE 17.—GEOLOGICAL FORMATIONS IN SASKATCHEWAN

Era	Period: Time Estimate Years*	Epoch	Formations in Saskatchewan	Thickness, feet	Materials and Remarks
	2,000,000	Pleistocene		0–400 + -	Glacial deposits: lake clays, boulder clay, etc.
CENOZOIC	Tertiary 58,000,000	Pliocene			Erosion
		Miocene	Wood Mountain	50 +	Gravels, conglomerates, sandstones, etc.
		Oligocene	Cypress Hills	125 +	Gravels, conglomerates, sands, etc.
		Eocene	Swift Current	50 +	Gravels, conglomerates, sands, etc.
		Paleocene	Upper Ravenscrag	800 + -	Erosion, Larimide Revolution. Buff, grey, etc., sands, shales, clays, coal
MESOZOIC	Cretaceous 65,000,000	Upper Cretaceous	Frenchman	20–190	Grey, etc., sands, shales, clays.
			Whitemud	12–75	White, grey, etc , sandy clays, clays, etc., partly refractory.
			Eastend**	20–100	Yellow, very fine sands, silts, etc. (mostly marine).**
			Bearpaw	700 + -	Dark shales (marine).
			Belly River	0–890	Sands, shales, coal (mostly non-marine).
			Lea Park	810–1,140	Light and dark gray shales (marine)
			Colorado	580–1,300	Dark gray shale (marine).
		Lower Cretaceous	Swan River*** Manville	270–630	Gray sands, shales, coal (marine and non-marine).
	Jurassic 32,000,000		Sundance	0–890	Gray shales, some limetsone (marine and non-marine). In wells.
	Triassic 28,000,000		Spearfish	0–390	Red and grey shales, dolomitic limestone, etc. In wells.
PALAEOZOIC	Permian 38,000,000				Erosion.
	Carboniferous 86,000,000		Charles Madison	0–900 0–555	Limestones, shales, etc In wells.
	Devonian 45,000,000		Minnewanka Waterways	0–100 450–1,000	Grey, red shales, limestones, dolomites, gypsum (marine, possibly some non-marine).
	Silurian 27,000,000		Elk Point	450–1,000	Limestones, gypsum, salt.
	Ordovician 67,000,000		Winnipeg	0–300	Not reached in wells, outcrops of limestone in north.
	Cambrian 105,000,000				Erosion.
	Pre-Cambrian 1,450,000,000 + -				Granites, sedimentary gneisses and schists, etc.

*The figures here given for geological time are taken from "Historical Geology" by Moore, published by McGraw Hill, and are based mainly on age determinations of radioactive minerals by Kovarik and Holmes.

**All formations above the Eastend are non-marine.

***Swan River formation in the east and Manville in the west of map area.

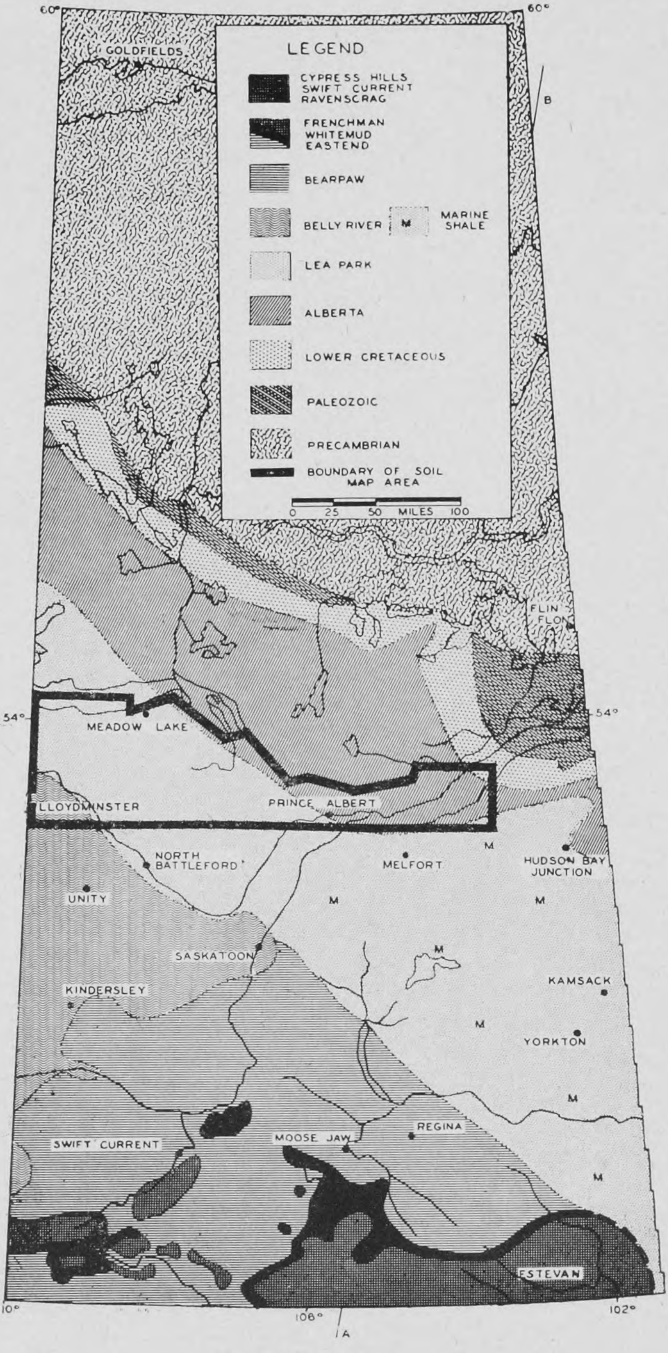


FIGURE 8

Geological Map of Saskatchewan.

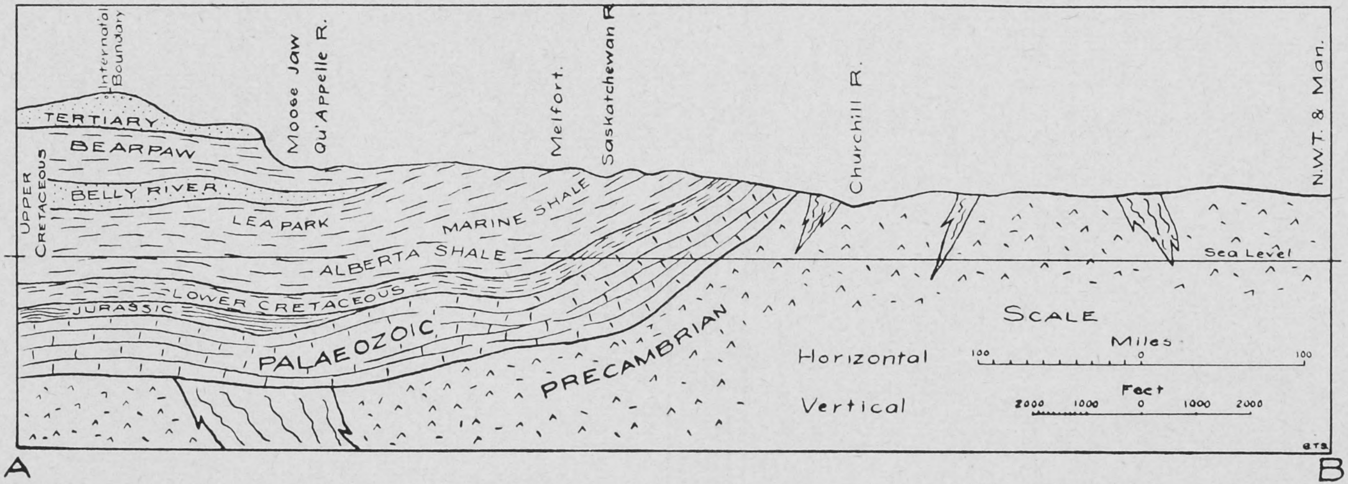


FIGURE 9

Diagrammatic vertical section from south to north across Saskatchewan showing the basin structure of the Pre-Cambrian surface. Palaeozoic limestones and at a later date Cretaceous and Tertiary sediments were deposited in this basin.

LOWER CRETACEOUS

Lower Cretaceous strata underlie the whole of the Saskatchewan prairies. They outcrop in the country north of the report area and because they are largely composed of sands there is a belt of light textured or sandy soil extending from north-west to south-east across northern Saskatchewan. Ile a la Crosse lies on this belt in the west and Whitefox in the east. The Lower Cretaceous underlying the report area is at variable depths, ranging from the surface in the east to about 1,800 feet deep in the south-west. The beds are sands and clays with some low grade thin coal seams and where there is suitable geological structure some of the sands carry gas and oil. The important heavy black oil fields of the Lloydminster area are in the Lower Cretaceous as are the Athabasca tar sands of the McMurray area, Alberta.

UPPER CRETACEOUS

The Upper Cretaceous is represented by a number of formations, some of which are listed in Table 17. The Colorado*, Belly River, and Lea Park formations directly underlie the surface deposits in various parts of the map area and the distribution of these rocks is shown on the geological map (Figure 8). There are changes in the formations from west to east and differences in the eastern part have necessitated the use of other names.

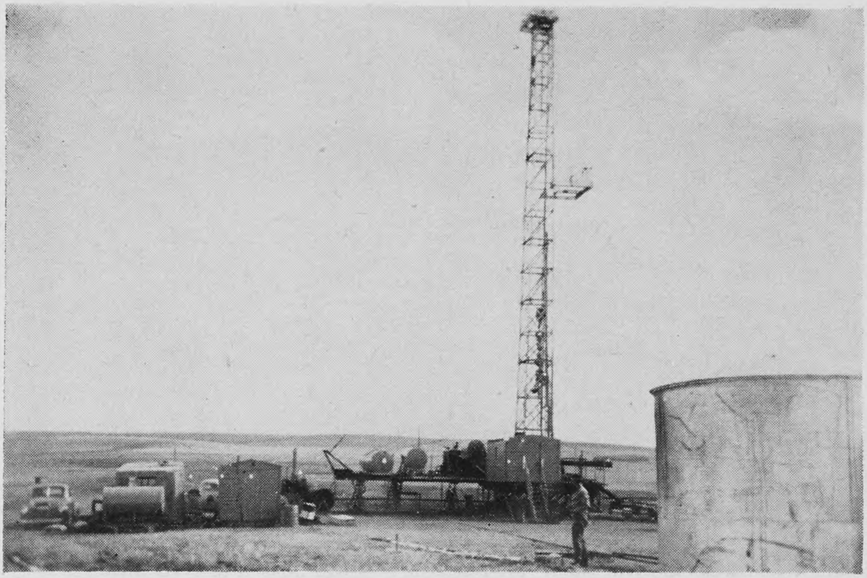
The following table gives the correlation of beds in the east with those in the west.

The Colorado and equivalent beds of the east are usually dark grey in colour and contain bands of oil shale. Outcrops of oil shale are present in the Porcupine Hills, south of Hudson Bay (Junction), along the Carrot River north of Melfort, near the forks of the Saskatchewan River, and at Flotten Lake, north of the Meadow Lake settlement. In glacial times the ice passing over the area underlain by the Colorado shale must have taken up a load of the material and incorporated it with the stones and boulders to form the morainic deposits. Some of the shale beds are brittle and do not slake down in water with the result that solid fragments are to be found in the glacial drift. However, a considerable proportion of the shale series readily breaks down on moistening and the clay content of some of the drift is derived from these beds.

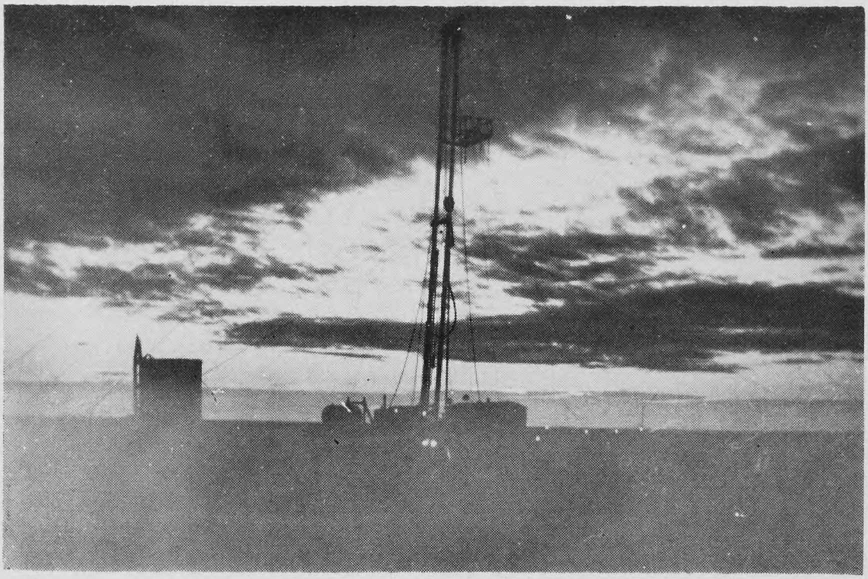
Many important gas deposits have been found in the Colorado formation in various parts of the Western prairies. In Alberta there are the important Medicine Hat, Bow Island and Viking gas fields. In Saskatchewan, small amounts of gas have been found in these shales in the Kamsack district, near Bertwell—a small town south of Hudson Bay (Junction) and also at Unity and Lloydminster. In Alberta, the Joseph's Lake field is producing oil from the Viking sand member of the Colorado formation. So far no oil has been found in the Colorado of Saskatchewan but the formation is one that is considered favourable and the prospects of discovering both oil and gas in it are promising. In the report area the formation is relatively close to the surface and, therefore, relatively easy to prospect with the drill.

*The name Alberta was used in previous reports. However, Alberta was the name given to the formation in the southern foothills and it is considered more appropriate to use the term Colorado for the plains area.

PLATE 36



Drilling operations—Saskatchewan, 1950.



Drilling operations—Saskatchewan, 1950.

TABLE 18.—CRETACEOUS CORRELATION IN WEST AND EAST PARTS OF MAP-AREA

		WEST			EAST		
		Formation	Member	Thickness feet	Formation	Member	Thickness feet
Upper Cretaceous	Montanan	Belly River Series	Oldman	300-0	Riding Mountain		300 to 500
			Grizzly Bear	0-60			
			Ribstone Creek	160 + -			
		Lea Park		800	Vermilion River	Pembina	40-50
						Boyne	80 + -
	Coloradan	Colorado	1st White Specks	750		Morden	100 + -
			2nd White Specks		Favel	Assiniboine	100 + -
						Keld	
			Viking Spinney Hill		Ashville		150 + -
Lower Cretaceous		Manville	Colony	140	Swan River		300 + -
			Silverdale	280			
			Dina	130			

The **Lea Park, Riding Mountain, Belly River, Bearpaw** and **Eastend** constitute a geological series known as the Montanan. The Lea Park shales underlie the country north of Lloydminster and the Belly River beds are present in the extreme south-west of the map area. The Riding Mountain, Bearpaw and Eastend are present in the country south of the map area as seen on the geological sketch map (page 210). The series is a related group of formations laid down under fluctuating conditions. The Lea Park is marine; the succeeding Belly River is mainly non-marine, consisting of beds laid down as delta, lake and swamp deposits; the Bearpaw is marine; the Eastend is also marine, but the beds are sandy and were laid down in near shore conditions as the seas receded. The sea in which, or adjacent to which, these beds were deposited is referred to as the Pierre Sea; it extended north to south from the Arctic to the Gulf of Mexico and west to east at its maximum from the foothills area of Alberta to some line east of the present Manitoba escarpment. The fluctuations of this sea were mainly due to upliftings in the mountain region to the west which caused deltas and alluvial plains to form along the west margin of the sea, thus at times restricting the sea to a narrow belt on the east side. The Belly River beds were formed during the major fluctuation and thus we find, in western Saskatchewan, that the marine beds—Lea Park and Bearpaw—are separated by the non-marine Belly River, whereas in eastern Saskatchewan the marine conditions were maintained and a continuous sequence of marine beds is to be found. The marine beds of the east part of the province equivalent to the Lea Park, Belly River and Bearpaw of the west are the Riding Mountain. Further south in the United States they are called Pierre shale.

The Lea Park, Bearpaw, and Riding Mountain are very uniform in character and, as will be seen from the map and section (Figures 8 and 9), underlie most of the prairie area. They are usually

medium grey in colour. They are soft, slake easily with water, and on moistening expand to form a highly plastic clay. On drying the clay checks or forms a honeycomb-like surface caused by shrinkage. The expansion on moistening is caused by the presence of a high percentage of the clay mineral bentonite. The shales are generally devoid of lime ($CaCO_3$).

Fossils of marine shell fish* are common in these shales and are mostly found in limestone or ironstone concretions which are distributed irregularly or in layers in the shales. Fragments of marine reptiles—Plesiosaurs and Mosasaurs have been found in outcrops along the South Saskatchewan River.

For the most part these shales are hidden, being covered by the glacial drift, but in some of the valleys and hillsides of southern Saskatchewan outcrops can be seen, appearing as patches of dark grey or brownish clay, almost or entirely devoid of vegetation. On the surface of these barren patches there are often a number of glistening crystals which sparkle in the sunlight and can be seen from a distance. These crystals are the mineral gypsum.

Most of the clay content of the glacial drifts in Saskatchewan have been derived from these marine shales. Much of the shale contains an appreciable amount of pyrite** which on oxidation gives an acid reaction and the resulting clay is incapable of supporting a good vegetation. However, in many places the mixing by ice of limestones and other calcium bearing minerals with this clay has given rise to a fertile soil.

The Belly River beds consist of clays, sandstones and coals. Lignite coal of this age is known to occur at Fielding, Brock, Kelfield, Salvador, Unity, and other places. Little attempt has been made to develop these seams in Saskatchewan. Belly River coals are mined at Taber and Lethbridge in Alberta. Bones of numerous reptiles, especially swamp-inhabiting types, have been preserved in this formation. The best remains of Belly River dinosaurs, including the carnivorous Tyrannosaurus-like forms and herbivorous duck billed forms, have been found in Alberta, along the Red Deer River near Steveville; but fragments of bones and teeth are common in the outcrops south of Unity, Saskatchewan.

The direct influence of the Belly River formation on the soils is not clearly seen, but the sands were resorted by water action following glaciation and the sandy soil of the country west of Unity, of the Great Sand Hills and other areas in the western part of the province, have derived some of their sand from the Belly River formation.

Very fine textured sands of the Eastend formation overlie the Bearpaw shales. They occur as a narrow band bordering the hill area of the south, where they are overlain by later beds. Thus the

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*A list of fossils in the Bearpaw shales of Saskatchewan with the localities of the finds is recorded in the Geological Survey Memoir 176, "Geology of Southern Saskatchewan," 1935, pp. 123-126.
The most common fossils are the cephalopods—**Baculites** which had a long straight shell with oval cross section, **Scaphites** and **Placenticeras**, both coiled shells, the former with a rough surface, the latter usually smooth. The pelecypods (clams) are common and include **Inoceramus** and **Arctica.**

**Pyrite, sometimes called Fool's Gold, is a sulphide of iron. On oxidation this mineral forms iron oxide. Sulphuric acid, which is also formed, quickly reacts with calcium carbonate to form gypsum and with sodium compounds to form sodium sulphate (white alkali).

general position of exposures of these sands is represented on the map (Figure 6) by the thick boundary line between the Tertiary and Upper Cretaceous areas. The sands were deposited under marine conditions, and mark the final retreat of the sea from this area. The many hundreds of feet of sediments that overlie this formation accumulated on alluvial plains and contain no evidence of a later submergence.

The Whitemud formation of Upper Cretaceous age and all the formations above it, including those of Tertiary age, as listed in Table 17, are present only in the extreme south of the province. They are not described here because of their remoteness from the map area. It seems unlikely that there was deposition of Tertiary beds in the present map area; and it is concluded that most of Tertiary time was one of erosion here, while deposition of sediments in lake and river flood plains was taking place in the south. Pliocene time was one of erosion, not only in the map area but also in the south, and during it many hundreds of feet of material were removed from the prairies.

When we attempt to visualize the events of Mesozoic and Tertiary times, the most striking feature is the bringing in of millions upon millions of tons of material from the west to this region, followed by the transfer of some of that material on to the Lower Mississippi and Gulf Coast regions. Most of the sediments must have come from the area west of the Rocky Mountain trench at a time prior to the building of the Rockies. Following the Larimide Revolution, sediments were derived from the Rocky Mountains. During the periods of erosion, material was being carried from this area and we are forced to conclude that most of it was taken by rivers draining to the south, for no traces of Tertiary formations have been found to the east or north-east on the Pre-Cambrian shield, and it seems doubtful if any great thickness of Tertiary deposits can be buried beneath Hudson Bay. It may be difficult to understand the vast changes that have taken place in even a structurally simple region such as this. Some appreciation, however, may be gained by considering the vast amount of material that is being moved at the present by a river system such as the Mississippi, which transports about four hundred and six million tons of sediment* and one hundred and thirteen million tons of salts from the Missouri Plateau and interior plains to the Gulf of Mexico every year. It thus becomes possible to realize that, during geologic time, many cubic miles of earth can have been moved from one region to another, in response to general adjustments in level of the earth's surface. This process is always at work, the surface of the prairie is always changing, and we cannot conceive of the geographical features we know today surviving into future geological periods.

GLACIAL GEOLOGY

Overlying the bedrock formations which have been described above is a mantle of glacial drift. This mantle is variable in thickness and usually heterogeneous in composition and is the result of the in-

*This sediment amounts to 0.00223 inches over the whole of the Mississippi drainage basin (1,244,000 sq. miles) in a year. At the same rate of transportation 185 feet would be removed in one million years, and in 10 million years, the possible length of the erosion phase of Pliocene time, 1850 feet of strata could have been removed.

tense glaciation which affected this country during glacial times. Before discussing glaciation it is well to appreciate that it is these glacial deposits which form the parent materials of virtually all of our soils. Moreover, the glacial drift is essentially formed from the bedrock material, the weathered and eroded bedrock having been transported, mixed and re-deposited by the ice.

In Pleistocene time this area, like all of Canada except the Yukon, was covered by an ice sheet, or rather by a succession of ice sheets since it is generally recognized that there were four stages of glaciation. The four intervals of cold and ice formation were separated by milder intervals or inter-glacial stages, during which the ice disappeared and moderate or cool climatic conditions set in. Forest and prairie belts became established, as proved by the finding of wood and old soils between glacial deposits in some wells and cut banks.

The possible causes of glaciation cannot be discussed here but one of the causes, and probably the one most essential, is high winter precipitation of snow. It is likely that if there was a very high winter snowfall in northern Saskatchewan, glaciation would take place and continue as long as high precipitation kept up. The short summer not being sufficient to melt all the snow, lowering of the temperature and spread of the ice would naturally follow.

In glacial times, some thousands of feet of ice accumulated in the country to the west of Hudson Bay, spreading in all directions. This is known as the Keewatin Ice Sheet. Labrador had a similar ice cap, and the Rocky Mountains were also strongly glaciated. The average thickness of ice in the Keewatin sheet is considered to have been 8,000 feet; at its maximum advancement it covered the whole of Saskatchewan, extending south of the International border.

Knowledge of the work of ice has been gleaned from the studies of mountain valley glaciers and of the margins of existing ice caps, and has made possible deductions with regard to the Pleistocene glaciations. The great thickness of ice at the central region of accumulation gave rise to pressure at the base and to gradual movement. Soil, disintegrated rock and hard rock masses were picked up by the ice in the northern sections; the rock masses would act as graving tools on the floor over which the ice was moving, so that erosion as well as transportation was accomplished. Boulders of Pre-Cambrian rocks and of limestones were carried south and mixed with shales and other sediments which were the surface rocks of the prairie region. Overloading at the base of the ice sheet, where much soft clayey material was collected, would cause lodging of that portion near the floor, and movement would then be continued by overriding in the upper layers of the ice. This lodging must have been a common feature of the Keewatin sheet in the area, since the direction of the movement was opposed to the slope of the land. To account for the movement of the ice, apparently up hill, it must be remembered that the greatest thickness of ice was in the north-east and the ice surface was inclined down towards the south and west.

The deposits resulting from glaciation can be grouped conveniently as those due to deposition from (a) ice, and (b) water. The

first group (a) are generally called moraines, and the materials composing them are heterogeneous mixtures of any materials that the ice may have picked up in its travel and finally dropped on melting. The terms **boulder clay** and **glacial till** are frequently used for these mixed materials.

A **terminal moraine** is the deposit formed at the extreme termination of the glacier where the ice front remained fairly stationary due to a balance between the rate of melting and the supply of ice reaching that region.

A **recessional moraine** is almost identical with a terminal one, but was formed during stages of retreat, at times when there was a temporary balance between melting and ice accumulation.

A **ground moraine** is the drift which became lodged at the base of the ice sheet or in the ice, and was left behind when rapid melting took place.

The washing effect of the water flowing over the deposits has often caused a sorting of the materials so that patches of boulder clay, of sorted gravels or sands and pond or lake silts and clays are to be found. This type is called **modified drift** or **resorted till.**

The topographic features are sometimes expressive of the type of moraine. In general, terminal or recessional moraine country is strongly rolling, with numerous pot holes, and is often stony; but there are exceptions, and sometimes the country is gently rolling. In low areas the moraine may be covered by later lake deposits. Ground moraine country is usually almost level or only gently rolling. Potholes are present, and may have resulted from the delayed melting of buried masses of ice. Stones are present, but are usually not abundant on the surface. In a few localities extreme stoniness may have been produced by water erosion as indicated below.

The second group (b) consists of outwash and lacustrine deposits. On melting, a great quantity of water was liberated at the ice front, since every eight hundred feet of ice would produce one million tons of water per acre. Accepting the average thickness of the ice sheets as eight thousand feet, about eight million tons of water were released over each acre of land. It must be remembered that while this vast quantity of water was dispersed in a fairly gradual manner, there were many opportunities during the summer months for torrential floods and for sheets of water to sweep over the land, modifying moraine deposits, giving rise in some places to stony belts where the finer material was swept away and leaving accumulations of stones on the surface.

Outwash deposits consist of roughly or well sorted beds of sand and gravel. They were deposited in front of the terminal or recessional moraines by water action.

Eskers and **kames** consist of sorted gravels or sands which were deposted by water beneath or within the ice. Eskers, as left after the ice melted away from the country, are relatively low, sinuous ridges and were built by streams which were flowing beneath the ice. Kames are hills or mounds of gravel. The gravel was washed by water and accumulated in pockets within the ice.

Lacustrine deposits are clays, fine silts and some sands, all well sorted, that have settled out of water in great lake areas.

The formation of great lakes at the recession of the ice was due to the slope of the land. Wherever this was towards the north, the water, not having free drainage to the south, would back up against the ice or recessional moraine, flooding the adjacent country until the water rose to the level of some divide, when it would drain into a southern drainage system. One of the greatest glacial lakes in Canada was formed over a large area in Manitoba, and is known as Glacial Lake Agassiz. Ice stood to the north, preventing the normal drainage, so that the waters of this great lake found their way south through Minnesota, joining the Mississippi drainage system. At earlier stages of the ice retreat several great lakes existed in Saskatchewan. Figure 8 shows the areas underlain by lacustrine deposits and thus where lakes must have been. In the Regina area, Glacial Lake Regina was of considerable size and has been described by Johnston and Wickenden.* In later stages of glaciation, much of the water draining from Saskatchewan found its way by the Qu'Appelle Valley to Lake Agassiz. The extensive area bordering the South Saskatchewan River shown on the map as lacustrine clay was not flooded at any one time but was occupied by a succession of lakes as the ice front melted back to the north.

The most important lacustrine sediments are clays, which are often banded. Bands of heavy clay, due to slow settling in the winter season when the lake had frozen over and no additional sediment was being brought in, alternate with bands of coarser clay or silt due to more rapid summer deposition. Stones are absent or very rare, and the areas of lacustrine deposits are nearly level or only slightly rolling. Where materials of coarser grade, such as fine sand, were deposited, subsequent modification by wind action has given rise to dune topography.

Numerous valleys in Saskatchewan, which usually run in a north-west to south-east direction, are glacial drainage channels. Some were eroded by running water at the margin of the ice sheet during its retreat; others were outlet channels from the glacial lakes. Many of these valleys are quite deep and are either dry or have a series of chain lakes. They do not carry any volume of water at present, but simply serve local drainage.

The glacial geology of Saskatchewan is complicated because of the four glacial stages with intervening inter-glacial stages. Practically the whole of Saskatchewan was involved in at least one of the earlier glaciations; the most south-westerly advance of the last ice sheet may only have reached the Missouri Couteau, where a great terminal moraine extends north-west across the Province. The South Saskatchewan River cuts through this moraine in the country north of the town of Morse. A small area south-east of Wood Mountain seems to have escaped glaciation, and is driftless.

The glacial drift is variable in thickness. In some areas of Saskatchewan, particularly in the west and south-west, the bedrock

*"Glacial Lake Regina," W. A. Johnston and R. T. D. Wickenden. Trans. Royal Society, Can. 1930.

is encountered at a depth of a few feet. Well records, at other places, show that the drift is from four to five hundred feet thick. Thick drift deposits no doubt accumulated in, and filled up, pre-glacial valleys, and there is evidence that in some sections the pre-glacial country was a strongly dissected plateau, and probably before the ice age the topography of Saskatchewan was of distinct badland character.

It is considered that glaciation was of considerable economic benefit not only because the present topography is more favourable for agriculture than the pre-glacial topography, but also because the physical and chemical composition of the surface material was improved. Where Cretaceous bedrock shale is exposed at the surface, the vegetation is sparse or absent, due to the impervious nature of the clay. The material is also often deficient in lime and contains pyrite which on oxidation gives the soil an acid reaction. If sodium carbonate is present or forms by carbonation of sodium-bearing minerals in the shale, it combines with products of oxidation of the pyrite to form sodium sulphate (white alkali). Both the acid reaction and the alkali condition are unfavourable to plant growth. Glaciation was effective in stirring up the bedrock material which lay at the pre-glacial surface. It incorporated with this material fresh mineral matter, containing a good supply of potash and phosphorus from the Pre-Cambrian rocks and lime from the Palaeozoic limestones. In some localities the influence of the bedrock material upon the soil is strong; for example, in the solonetzic soils of the Echo and Trossachs Associations the moderating effects of glaciation have been insufficient to overcome the undesirable characteristics of the bedrock clay shale which forms the bulk of the soil parent material.

SURFACE DEPOSITS AND THE SOIL

The importance of the geological origin and topography of parent material in the classification of soils has been stressed in previous sections of this report. It is desirable, therefore, to indicate the extent to which these factors are important in the present surveyed area and to point out the geological significance of the soil map.

The primary classification of the soils leads to the recognition of broad belts or zones in which the majority of the soils reflect the impress of the climate and the associated vegetation. In general, and over long periods of time, the influence of climate and vegetation tends to reduce the importance of the geological factors. Thus, the black soils, formed under grassland, differ markedly from the grey soils, formed under forest vegetation, even when the parent geological deposits are similar in both areas.

The above comparison is valid when dealing with broad regions or zones. Within any one zone, however, variations in the geological factors are reflected in the soils. Thus, all black soils are not alike, but may differ in texture, structure and other profile features as well as in topographic expression. These differences can be related to variations, both in the lithological nature and in the mode of deposition of the parent geological deposits.

In order to deal with the soil differences related to these geological variations, use is made of the Soil Association or Catena. The Association is defined as a group of related soils occurring in close association and developed on similar parent geological deposits. Thus, in any soil zone a soil association is established for the related soils found on each kind of geological deposit that can be identified and separated in the field. This definition introduces the geological factors into the classification of soils.

To the geologist, the Soil Association represents a geographical area composed of reasonably uniform surface deposits of similar origin which form a recognizable landscape or land form pattern. It follows, therefore, that the soils forming a given association possess some degree of uniformity in range of texture (mechanical composition) and in chemical composition. These features are inherited from the parent material. It is true that soil forming processes, as represented by physical, chemical and biological weathering, may modify the original conditions so that the soil profile is not identical with the original parent rock. Nevertheless, it remains true that many of the important characteristics of a soil association are related to the geological factors.

On the soil map the soil associations are further sub-divided on the basis of differences in surface texture, topography, and, in some instances, degree of stoniness. All of these separations are made primarily because they directly influence the agricultural use and value of the soil. For general purposes it might be sufficient to state that a certain soil association is found on morainic knob and kettle topography; but for agricultural purposes it is important to know how rough and steep the surface is and whether or not it can be cultivated. Hence, the separation on the map of strongly rolling and hilly (non-arable) areas from the more desirable topography classified as gently to moderately rolling.

Finally, it should be stated that the various soils which make up a soil association are referred to as Members or Series. Each member soil is identified by profile features and it also occupies a specific segment of the association landscape. Hence, while only the association is outlined on the soil map, a more detailed picture of the area may be obtained by reading the description of the soil association and its member profiles as given in the report.

The relation between the major types of surface deposits and the soil associations of the present surveyed area is shown in Table 19. The established soil associations are indicated by place names, such as Oxbow, Waseca, etc. Other soils are classified as undifferentiated associations and are referred to by descriptive names only. These undifferentiated associations represent either young, immature soils that do not possess well developed profiles, or complex soil areas whose individual soils could not be separated on a reconnaissance map. Alluvium, Dune Sands, and Undifferentiated Sands represent the first group, and Meadow, Peat and Muskeg soils the second.

Referring to Table 19, the surface deposits are listed according to their mode of origin, beginning with the more recent deposits and

ending with those composed in part of pre-glacial sediments. The various deposits and related soil associations are discussed below:

1.—**Recent deposits** include river alluvium of present flood plains, recent mineral deposits of ponds and shallow lakes, and organic or peat deposits of wet bogs and other undrained sites. Most of these deposits are associated with flat to depressional topography and poor surface drainage, and the mineral soil profiles are usually weakly developed or immature as compared with the soils of well drained uplands.

Alluvium consists of variable textured stratified deposits bordering river and creek channels. Compared with the prairie region the acreage of Alluvium in the present map area is insignificant. The main feature of Alluvium is the lack of well developed soil profile features due to the recent nature of the deposits and the periodical flooding.

Saline (Alkali) soils consist chiefly of variable alluvial and pond deposits which contain undesirable quantities of soluble salts—chiefly sulphates of sodium and magnesium. In the present area the Saline soils consist of feebly developed black soils. They occur chiefly in the areas of thin drift and modified bedrock extending from near Lloydminster to Paradise Hill. It is likely that the bedrock shales are the source of the salts.

Meadow soils consist of variable textured, poorly drained soils of ponds, former shallow lakes and wet alluvial areas. They are characterized by dark "mucky" (humus) surface horizons and lighter coloured subsoils, usually highly calcareous. Meadow soils occur chiefly in the Black-Grey soil areas and the adjoining portion of the Black Soil Zone. In the Grey Soil Zone the Meadow soils tend to be replaced by peat soils.

The Organic (peat) soils represent a distinct group, being composed in whole or in part of organic material derived from sedges, sphagnum moss, shrubs, and trees. In the Shallow Peat soils, the organic surface ranges from a few inches to usually less than 24 inches in thickness. The underlying mineral soil is regarded as part of the soil profile, since it is modified by the peat layer. The Deep Peat or Muskeg soils consist of two to four feet or more of organic material and the underlying mineral soil is regarded as a deposit below the true soil profile.

Organic soils vary in character according to the kinds of plant material, the degree of decomposition, and the reaction. In general, Muskeg soils consist of raw, undecomposed peat, while the Shallow Peats are characterized by more decomposed organic material.

2.—**Aeolian deposits** represent material deposited by the wind, but in the present grouping alluvial-lacustrine deposits partially reworked by the wind are also included. Topographic features vary from low hummocks to well developed dunes and smooth undulating ridges.

Dune Sands are feebly developed soils consisting essentially of loose sand with a very low organic matter (humus) content. **The**

TABLE 19.—SURFACE DEPOSITS AND RELATED SOIL ASSOCIATIONS

Soil Zone	Recent (transported and organic)	Aeolian (wind deposited and wind modified)	Glacial Lacustrine and Alluvial (some lake-modified boulder clay)	Glacio-Fluvial (outwash, kames and eroded boulder clay)	Glacial Moraine (morainic and till plain boulder clay)	Thin Boulder Clay and Modified Bedrock
Black (Parkland)	Alluvium Saline (Alkali) Meadow	Dune Sands Undifferentiated Sands (in part) Meota (in part)	Blaine Lake Canora Meadow Lake Meota Undifferentiated Sands	Whitesand	Oxbow Lloydminster Eroded	Waseca Onion Lake Meota Soils Over Bedrock Clay Eroded
Black-Grey (Parkland-Forest Transition)	Alluvium Meadow Shallow Peat	Dune Sands Undifferentiated Sands (in part)	Tisdale Kamsack Beaver River Nipawin Whitefox Shellbrook Weirdale Carrot River Makwa (in part) Kelsey Undifferentiated Sands	Glenbush	Whitewood Horsehead Makwa (in part) Pelly Paddockwood Eroded	Eroded
Grey (Forest)	Shallow Peat Muskeg (deep peat)	Pine (in part) La Corne (in part)	Arborfield Dorintosh La Corne Sylvania Pine Garrick	Bodmin Smeaton	Waitville Loon River Garrick (in part) Eroded	

succession of individual dune ridges and hollows forms a rough surface. Dune Sands are mapped in the Black and Black-Grey soil areas. In the Grey Soil Zone the former Dune Sands have been leached under the forest cover, and the resultant soils are classified as the Pine Association.

Undifferentiated Sands are considered to be of alluvial origin, but some of them have been re-worked by the wind into the form of hummocky or miniature dunes and low smooth ridges. In general, weakly developed, immature soil profiles occur, of a sand to loamy sand texture. The better developed profiles occur in the Grey Soil Zone, and here the soils on Undifferentiated Sands are classified as the Pine and Sylvania Associations.

The Meota and La Corne soils included in the Aeolian group consist of fine to very fine sandy loam black and grey soils respectively. The parent deposits consist chiefly of lacustrine and alluvial materials re-worked by the wind. It is also possible that some of the smoothly rolling areas of Meota and La Corne soils represent loess-like deposits of very fine sand and silt.

3.—**Glacial Lacustrine and Alluvial deposits** consist of clays, silts and fine to very fine sands laid down in lakes formed in front of the retreating ice sheet; some of the sands may represent delta deposits from streams entering the lakes. There are also extensive deposits of alluvial sands and silts above the present channels of the Saskatchewan and Carrot Rivers.

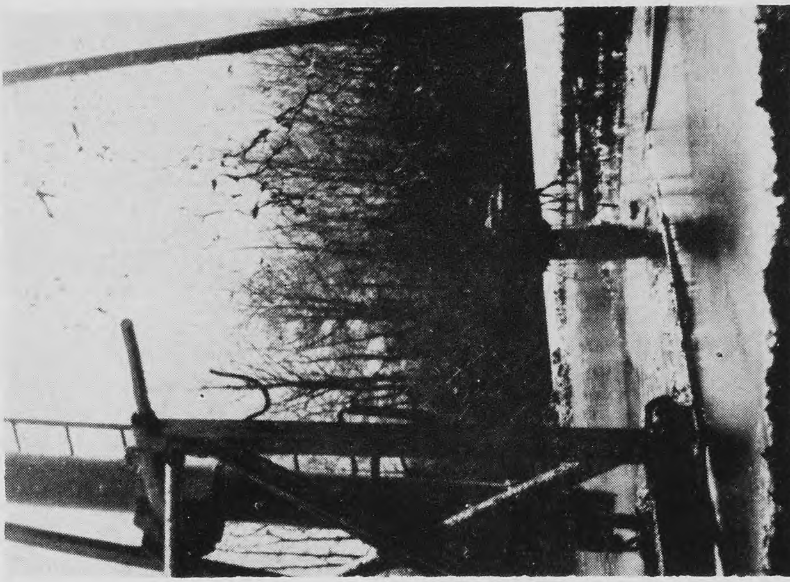
The Black soils include the Blaine Lake Association developed on silty lacustrine deposits, the Canora on highly calcareous silty deposits and the Meadow Lake on silty clay deposits which have given rise to thick black solonetzic structured soils. The Meota Association represents the fine textured sandy lacustrine-alluvial deposits which have not been modified by wind action.

In the Black-Grey soil region the Tisdale Association is developed on lacustrine clay and heavy clay; the Kamsack and Beaver River on silty lacustrine deposits; and the Weirdale on highly calcareous silty loam to clay deposits. Nipawin, Whitefox and Carrot River soils occur on the sandy-silty alluvial deposits bordering the lower Saskatchewan and Carrot Rivers. The Nipawin is somewhat heavier textured (more silty) than the Whitefox, while the Carrot River represents sandy loam soils formerly covered with thin peat. Makwa and Kelsey soils represent modified boulder clay deposits associated with glacial lakes.

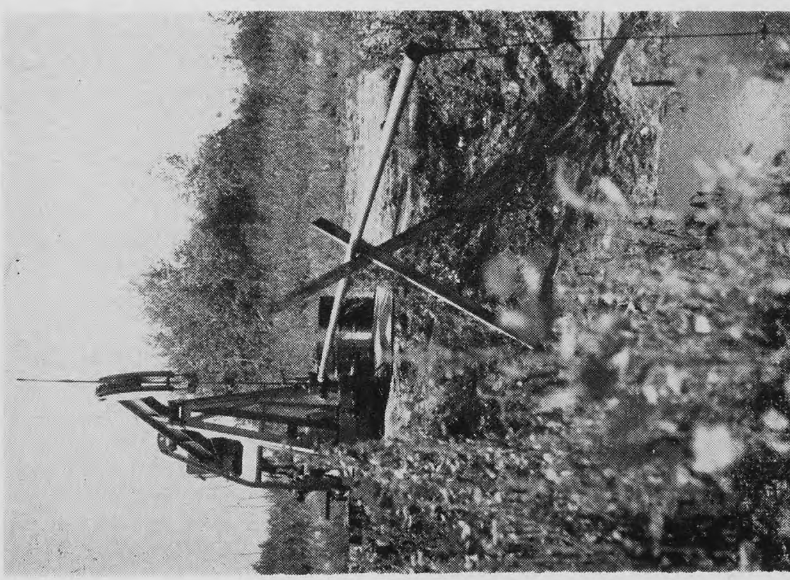
In the Grey Soil Zone, the Arborfield Association is developed on heavy textured clay deposits and the Dorintosh on silty lacustrine deposits. La Corne is the grey soil equivalent of the Whitefox soils, both developed on alluvial sandy loam deposits. Sylvania soils represent alluvial and lacustrine sandy loams, while Pine soils are alluvial sands and loamy sands. Finally, the Garrick Association represents grey soils on lake-modified boulder clay, similar to that encountered under the Kelsey Association.

The topography of most of the Glacial Lacustrine-Alluvial deposits ranges from level to undulating. A few areas are mapped as

PLATE 37



Uncontrolled well in Lloydminster field. For a time after completion this was a flowing oil well.



Pumping oil well in the vicinity of Deer Creek, Saskatchewan.

rolling and these represent either dissected areas or thin lacustrine deposition over moraine deposits. (Definitions of the topographic classes are given in the section on Soil Classification.)

4.—**Glacio-Fluvial deposits** consist chiefly of glacial outwash sands and gravels with nearly level topography, and kame deposits with rougher topography. In addition, stream-eroded boulder clay is included in this group. The latter deposit consists of surface glacial stones, gravel and sand overlying ordinary boulder clay, and is found in shallow eroded channels and along the margin of the deeper river channels, such as that of the Englishman River. While the stream-eroded boulder clay may not be a true Glacio-Fluvial deposit, it is convenient to place it in this group. From the point of view of agricultural use the eroded boulder clay, like glacial outwash, eskers and kames, gives rise to poor droughty soils.

In the present area the Whitesand, Glenbush and Bodmin Associations are developed on Glacio-Fluvial deposits of the Black, Black-Grey and Grey Soil Zones respectively. The Smeaton Association is found on the margin of the glacial lake area north-east of Prince Albert. The Smeaton soils occur on thin Glacio-Fluvial deposits overlying or mixed with glacial lacustrine clay. In places there is an intricate mixture of various deposits and related soils. Such areas are mapped and described as the Smeaton Complex.

5.—**Glacial Moraine deposits** include boulder clay deposited both as marginal moraine and as till plain or ground moraine. These deposits give rise to medium (loam to clay loam) textured soils, but they are quite variable with respect to the content of gravel, stones and boulders. In most areas they are a mixture of materials ranging in size from clay particles to boulders. Some of the till plain deposits have been partially sorted by water action, either as the ice melted or subsequently. This modification of the boulder clay involves the washing of finer materials from the higher places and their deposition in low places, and various degrees of modification are possible, depending upon the topography.

Glacial Moraine deposits are characterized by a "wavy" type of surface relief consisting of a succession of knolls and ridges, intermediate slopes and depressions or kettles. The degree of topographic expression varies considerably, ranging from very gently undulating to strongly rolling (0.5% to over 20% slopes). Some of the modified deposits may be nearly level.

In the present mapped area the Oxbow, Whitewood and Waitville Associations are Black, Black-Grey, and Grey soils respectively. They are developed on undifferentiated boulder clay. The term "undifferentiated boulder clay" has been used by the Soil Survey to cover large areas of relatively uniform boulder clay in Southern Saskatchewan. This material has not yet been studied in sufficient detail to show whether it is all of similar origin and composition. Because of the large extent of this boulder clay it is considered likely that further studies may result in the recognition of important differences in the deposits; this will lead to the establishment of new soil associations on each type of boulder clay.

The Horsehead and Loon River Associations are Black-Grey and Grey soils respectively, developed on boulder clay which contains fragments of shale and is relatively low in lime carbonate.

The Makwa and Garrick Associations are Black-Grey and Grey soils developed on modified boulder clay bordering glacial lake beds. The Pelly and Paddockwood Associations consist of degraded black and wooded calcareous soils respectively, developed on modified calcareous boulder clay.

Eroded soils represent truncated soil profiles of steep valley slopes and escarpments, developed on boulder clay exposed by geological erosion.

6.—**Thin Boulder Clay and Modified Bedrock deposits** occur in the western section of the surveyed area, notably on the upland between Lloydminster and Paradise Hill. The lower portions of the upland are composed of thin boulder clay deposits which form the parent material of the Waseca soils. These are black solonetzic soils with gently to roughly undulating and rolling topography. The roughly undulating areas are characterized by a series of steep-sided ridges mostly trending east-west. In some places these ridges are crossed by others with a north-south trend.

The Modified Bedrock deposits occupy the higher elevations of the upland, but may also be found in basins and former channels. The material consists of dark grey heavy clays derived from weathered shale, and the soils developed on them are classified as the Onion Lake Association. A few stones occurring on the surface and the presence of loamy textured soils in some places indicate that the area was lightly glaciated. The topography is chiefly well drained, rolling to hilly, lacking the knob and kettle pattern typical of morainic deposits.

In some rolling areas, sandy light loams and very fine sandy loam deposits overlie the bedrock clay. It is possible that the sandy deposits are of aeolian origin, since they appear to form a fairly uniform cover from the lower slopes to the crests of the ridges. These deposits are mapped as Meota sandy loam soils over clay.

The soils associated with the bedrock in this area belong to the Black Soil Zone. A few small areas of Eroded soils are associated with bedrock exposures along valley sides and escarpments.

The foregoing discussion of Table 19 indicates the relationship between the major surface deposits of the area and the soil associations so far established. A more detailed soil survey would involve further studies of the surface deposits and would undoubtedly lead to the recognition of additional types of parent materials and hence of additional soil associations.

Even on the present scale of mapping a more detailed picture of the geological and soil relationships can be obtained by a study of the individual soil members that make up a soil association. The soil members represent local soil landscapes within the major association landscape and thus indicate soil variations caused by local topography, drainage and geology.

ECONOMIC GEOLOGY

GROUND WATER

There are two geological bedrock horizons underlying parts of the map area which are good water reservoirs. These are sands in the Belly River and the Lower Cretaceous formations respectively. The Belly River sands underlie only a limited area in the southwest part, particularly in the Lloydminster-Maidstone-Paynton districts. The town of Lloydminster obtains its water from this source where the wells are about 200 feet deep. The water is of good quality, but contains a little iron that is slightly objectionable to the taste, particularly when the water is not absolutely cold. In the district surrounding Lloydminster water is obtained from one of three or four sands that are within 300 feet of the surface; the water in the top sand is usually more alkaline than that in the lower sands, and a better quality of water is therefore obtained from the lower beds. South-east of Lloydminister the water conditions, with respect to the Belly River, are variable and the water bearing beds are not always present. In parts of the Maidstone and Waseca districts the water sands are sometimes cemented with lime so that the porosity and permeability are low. However, in spite of this, good water supplies have been obtained by shooting the sand horizon. This is a procedure comparable to shooting an oil well to open up the pores in a tight oil sand.

Lower Cretaceous beds underlie the whole of the map area, but in much of it the formations are too deep for economical water production; moreover, the water is usually unfit for use because of its salt content, which is about eight per cent. It is only in the extreme eastern parts of the area, where the Lower Cretaceous is at the surface or a short distance below, that it contains fresh water fit for use. There are not many wells which get their water from this source, but the writer considers that good water can be obtained in the area of the outcrop of the Lower Cretaceous and also in a belt, some twenty to thirty miles wide, south of this outcrop. The belt runs in a south-east to north-west direction across the northern prairie. It takes in the Whitefox country in the south-east but is too far north of settlement in the central and north-western areas to be of importance.

Except in those limited areas mentioned above where the Belly River and Lower Cretaceous can yield water, wells have to obtain their supply from the glacial drift. In some places the drift carries good water in pockets of sand and gravel present in the boulder clays but the distribution of the water is very irregular and in much of the map area the conditions in the drift are poor. The poor conditions may be because the drift is thin or because it consists of clay with very few sand and gravel pockets. In those areas where water is hard to get, the surface water should be conserved in dugouts or in local reservoirs formed by damming coulees and channels. It is often thought that because the northern settled areas support good tree vegetation, water is no problem, but this is far from true in parts of the area where clay drift is underlain by thick clay formations such as the Lea Park and Colorado shales. Because of these geological conditions much of the eastern and northern settled areas of Saskatchewan have a more difficult ground water supply problem than that of the open prairie areas.

GRAPHIC LOG

LLOYDMINSTER GAS & OIL FIELD

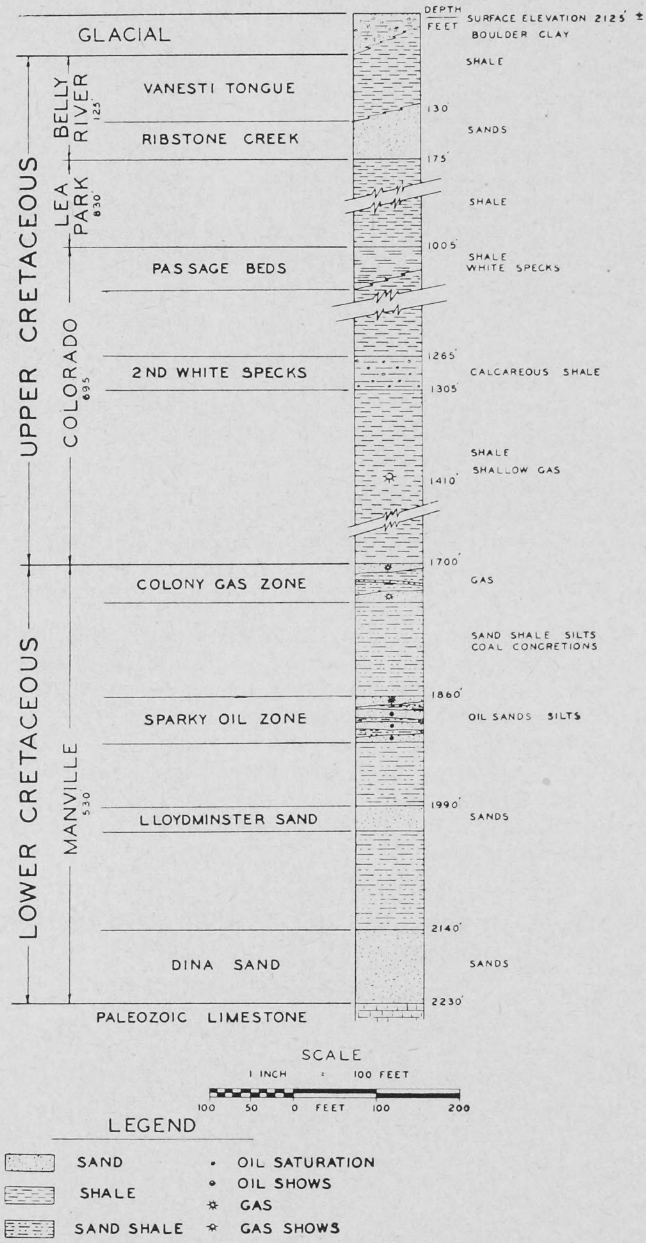


FIGURE 10

Diagrammatic section of formations in oil well.

GAS AND OIL

Gas in commercial quantity was first discovered near Lloydminister in 1934. Shortly after this discovery some oil was found, but the first attempts at commercial production were not successful and it was not until 1944 that any extensive developments took place. Since that time there has been considerable expansion and the Lloydminster oil field ranks fourth among Canadian fields, its current production being exceeded by those of Leduc, Redwater and Turner Valley. Part of the Lloydminster field is in Alberta, but the producing area in Saskatchewan is within the present map area. The oil is a heavy black type* and is obtained from the Lower Cretaceous beds, which are at a depth ranging from 1,700 feet to 2,200 feet. Most gas is found in a zone, known as the Colony**, at the top of the Lower Cretaceous, while nearly all of the oil is obtained from the Sparky*** zone which is about 150 feet lower.

The limits of the field have not yet been determined. There are three main producing areas, one being west of Lloydminster in the vicinity of Blackfoot, Alberta, while the other two are in Saskatchewan; both are south of the town of Lloydminster, the first being the Silverdale area about 6 miles south and the second the Lone Rock pool about 16 miles south and 8 miles east. There are several other producing pools in the Lloydminster field and all of them lie on a major terrace structure. The regional geological structure in this part of Saskatchewan is that of a gentle downslope (dip) of the beds toward the south-west; the amount of the slope is about seven feet to the mile and the terrace structure is a flattening of this regional incline.

The location of commercial oil pools on the terrace depends upon slight folding and thickening of porous sands in the producing zones. On the terrace, producing pools have been found at various places from Kitscoty in the north-west to Lone Rock in the South-east, a distance of over thirty miles. The width of this belt is about 8 miles. Other structures in the general area have been partially developed; these include ones in the Dina-Marsden area thirty miles south, the McLaren-Waseca area twenty miles west and the Maidstone area thirty-five miles south-east.

TABLE 20.—LLOYDMINSTER OIL FIELD PRODUCTION
(In Barrels—Refinery Deliveries)

Year	Saskatchewan	Alberta	Field Total
1934-44	331	49,106	49,437
1945	16,508	29,321	44,829
1946	136,874	76,187	213,061
1947	540,117	308,394	848,511
1948	856,821	652,237	1,509,058
1949	784,639	725,812	1,510,451
1950 (November)	952,579	764,299	1,716,878
Total	3,287,968	2,605,356	5,892,225

*The Specific Gravity varies from about 10° to 19° A.P.I. The average is about 15° A.P.I.

**The name Colony pays tribute to the settlement of the area by members of the Temperance Colonization Society (Barr Colonists) in 1903.

***The name of the first producing oil well drilled in 1944 was Sparky No. 1.

PLATE 38

Placer gold working along the North Saskatchewan River, 1938.

Ferry on North Saskatchewan River transporting oil well testing equipment.

At the present time there are 262 producing wells in the field, and of these 112 are in Alberta and 150 in Saskatchewan. The production is now about 170,000 barrels a month and Table 20 shows the production from the inception of the field.

Gas was discovered some years ago at Bertwell which is on the east side of the Province and is 20 miles south of the town of Hudson Bay. The gas is in a shale at a depth of about 200 feet. It is not abundant in quantity and has not been developed; however, its presence is significant and this evidence of gas on both sides of the Province gives encouragement to the hope that extensive finds of oil and gas will eventually be made. At the present time considerable exploration is taking place. This work consists of geophysical surveys and test drilling. The prospects are not confined to the Cretaceous beds and there is expectation of discoveries being made in the Palaeozoic beds which underlie the area. The discoveries of oil of lighter gravity than that of Lloydminster in Devonian beds at Leduc, Redwater and other areas on the Alberta prairie proves the possibilities of these rocks. The recent discovery at Virden in Manitoba makes it almost certain that commercial oil is present at various places beneath Saskatchewan and its discovery is only a matter of time. With the volume of exploration taking place at this time it can be hoped that the discovery will be made shortly. There are cycles of exploration fever and if discovery is not made shortly it will probably be a matter of waiting for some later cycle. The general evidence of oil is eminently satisfactory and it is safe to say that the Saskatchewan prairie, including the map area, is a potential oil country. This statement, however, does not imply that the oil will be easy to find. Experience shows that the initial finding in any area is usually costly and that there are many disappointments before final success.

ECONOMIC MINERALS

No great development of economic minerals can be expected in the map area. In the surface deposits there are likely to be clays capable of being used in making common bricks. These clays are fairly widespread, but no survey has been made to assess them nor would any useful purpose be served by making such a survey until bricks become of greater economic importance than at present.

In the country directly east of Hudson Bay (Junction) there are outcrops of Lower Cretaceous sands that have the necessary grade and quality for use in glass making. These deposits have been studied by Professor W. G. Worcester* at the University.

The Colorado shale formation contains beds that are bituminous. On heating, oil is distilled from these shales. In the distant future when present oil deposits have been exhausted these shales may become of economic value. There are very large quantities of them in the map area and outcrops have been noted at a considerable number of places such as in the banks of Etomami River south of Hudson Bay (Junction), along the Saskatchewan River near Nipawin, along the Carrot River north of Melfort, at Green Lake, and at Flotten

*W. G. Worcester—"Silica Sand"—Preliminary Report on the Silica Sand Deposits on the Red Deer River at Approximately Twp. 46, R. 30, W. 1st. Department of Natural Resources, Province of Saskatchewan—Report for year ended April, 1942.

Lake. These Colorado oil shales have also been observed in the cutting samples of almost all wells drilled in the Province.

Metallic minerals are rare in the area and the geological conditions of the area are such that no deposits other than small quantities of alluvial gold, and bog iron ore with traces of manganese can be expected. Small bodies of red ochre (bog iron ore) have been found in several places. The deposits are of spring origin, they are small and not of commercial value for the manufacture of iron. In some of these spring deposits there is a small quantity of black manganese oxide, but none of commercial quantity has yet been found.

Placer gold is present in small quantities at various points along the North Saskatchewan River. In Saskatchewan it seems to be most abundant in the west, from Frenchman's Butte to the Alberta border. The gold in this area has been worked very sporadically and in the depression years of the 1930's there were as many as a dozen parties of one or two men each washing the beach gravels and extracting small quantities of very fine gold. The writer visited the area in 1938 and at that time the operators were said to be getting about $3.00 of gold per day. The mode of occurrence and possible origin of the gold is discussed in a short report published by the Department of Natural Resources*.

REFERENCES TO THE GEOLOGY OF SASKATCHEWAN

Many reports dealing with the Geology of Saskatchewan have been published by the Bureau of Economic Geology, Department of Mines, Ottawa, some of which are listed below:

General—

Economic Geology, Series No. 1, 1947, Geology and Minerals of Canada.
Economic Geology, Series No. 5, 1933. Oil and Gas in Western Canada.
Economic Geology, Series No. 7, 1930. Prospecting in Canada.

Pre-Cambrian—

Summary Report, 1932, Part C. Amisk Lake Area, Saskatchewan.
Memoir 180, 1935. Mudjatik-Haultain Area, Saskatchewan.
Memoir 182, 1936. Geology of Lake Athabaska Region, Saskatchewan.

Plains—

Memoir 93, 1917. Southern Plains of Alberta (giving plates showing fossils). Out of print.
Memoir 163, 1930. Geology of Southern Alberta and South-western Saskatchewan.
Memoir 176, 1935. Geology of Southern Saskatchewan.
Memoir 182, 1935 Floras of the Whitemud and Ravenscrag Formations.
Memoir 221, 1940. Geology of the Southern Alberta Plains.
Memoir 232, 1941. Geology of East-central Alberta.
Memoir 239, 1945. Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan
Memoir 242, 1946. Cypress Lake Map-Area, Saskatchewan.

*F. H. Edmunds. "Placer Gold Along the North Saskatchewan River." Annual Report (Mines) Department of Natural Resources, 1939, p. 15.

Appendix

SOIL TEXTURAL CLASSES USED IN SASKATCHEWAN

TABLE 21.—SOIL SEPARATES (PARTICLE SIZES) ON WHICH THE TEXTURAL CLASSES ARE BASED

Separates	Diameter in Millimetres
Very Coarse Sand	2.0 –1.0
Coarse Sand	1.0 –0.5
Medium Sand	0.5 –0.25
Fine Sand	0.25–0.10
Very Fine Sand	0.10–0.05
Silt	0.05–0.002
Clay	Less than 0.002

TABLE 22.—SOIL TEXTURAL CLASSES AND THE PERCENTAGE OF VARIOUS SOIL SEPARATES IN EACH CLASS

I.—Soils containing less than 20% of silt and clay (sands and loamy sands): All sands contain less than 15% silt and clay.

1. Coarse sand—over 25% fine gravel and coarse sand, and under 50% of any other grade.
2. Medium sand—over 25% fine gravel, coarse and medium sand, and under 50% fine sand.
3. Fine sand—over 50% fine sand, or under 25% fine gravel, coarse and medium sand.
4. Very fine sand—over 50% very fine sand.
5. Loamy sands—15% to 20% silt and clay.

II.—Soils containing 20% to 50% silt and clay (sandy loams):

1. Sandy loam—over 25% fine gravel, coarse and medium sand.
2. Fine sandy loam—50% or more fine sand, or under 25% fine gravel, coarse and medium sand.
3. Very fine sandy loam—50% or more very fine sand.
4. Light loam—15%-20% clay, and over 50% sand.

III.—Soils containing over 50% silt and clay (loams to clays):

1. Loam—under 20% clay and under 50% silt.
2. Silt loam—under 20% clay and over 50% silt.
3. Clay loam—from 20% to 30% clay and under 50% silt.
4. Silty clay loam—from 20% to 30% clay, and over 50% silt.
5. Sandy clay loam—20% to 30% clay, over 50% sand.
6. Clay—over 30% clay.
7. Sandy clay—over 30% clay and over 50% sand.
8. Silty clay—over 30% clay and over 50% silt.
9. Heavy clay—over 50% clay.

THE CLASSIFICATION OF TOPOGRAPHY

The National Soil Survey Committee (N.S.S.C.) representing all soil survey organizations in Canada, has adopted a tentative classification of topography. It was agreed that the classification should either be used in the legends of soil maps or that the systems already in use in various regions should be defined in terms of the National classification.

In the present survey, the broad scale of mapping made it impossible to show all units of the National classification on the published map. Hence, a number of the classification units had to be combined under a single mapping unit. The relationship between the topographic classes used in the present survey and those adopted by the National Soil Survey Committee is indicated in Table 23. In very detailed soil surveys all units of the National System can be mapped.

TABLE 23.—TOPOGRAPHIC CLASSES SHOWN ON MAP, AND RELATED CLASSIFICATION UNITS OF THE N.S.S.C.

Topographic Class	Classification Units of N.S.S.C.
1.—Flat to Depressional	A_0, A_1, B_0, B_1.
2.—Nearly Level to Undulating	A_2, A_3, B_2, B_3.
3.—Roughly Undulating	$B_{3,2}$.
4.—Gently to Moderately Rolling	Chiefly B_4, B_5; local areas of A_4, A_5.
5.—Mixed Undulating and Rolling	Chiefly areas of mixed (B_2 to B_3) and (B_4).
6.—Strongly Rolling to Hilly	Chiefly B_6; some B_7 and A_6. A_7.

THE CLASSIFICATION OF STONY LAND

On the reconnaissance soil map only the larger areas of very stony and excessively stony land can be shown. However, frequent reference is made in the report to other stony classes. The following table lists the stony classes used by the Saskatchewan Soil Survey and which in more detailed surveys are applied to all soil areas.

TABLE 24.—DEFINITIONS OF STONY PHASES

S_0—Stone free.

S_1—Occasional stones—no serious handicap to cultivation.

S_2—Moderately stony—requiring removal, occasional stone pile in field and frequent stones along road.

S_3—Very stony—serious handicap to cultivation. Frequent stone piles in fields and many stones along roads.

S_4—Excessively stony—too stony to permit cultivation; shown on present map as stony phase (St.).

THE CLASSIFICATION OF SOIL STRUCTURES

Soil Aggregates.—Both cultivated soils and the horizons of soil profiles are composed of various soil aggregates. The term "aggregate" refers to a single mass or piece of soil consisting of many individual soil particles. Soil aggregates vary in shape and size and these variations are recognized in classifying the structure of soil profiles.

The structures most common to Saskatchewan soils are described below. Most of the structural aggregates listed may be further sub-divided according to size, as— small, medium or large cloddy; fine to coarse granular; thin to thick platy, etc. Their relative durability or resistance to pressure may be indicated by such terms as weak, soft, hard, very hard, compact.

TABLE 25.—DEFINITIONS OF SOIL STRUCTURAL AGGREGATES

1.—**Cubic Structures.**—Soil aggregates of cubic or more or less rounded forms, approximately equal in vertical and horizontal cross-sections.

Blocky.—Large cubic aggregates with well defined sides and edges, 4" or more in diameter. Found in B horizons of light textured soils and in some slightly degraded black types.

Cloddy.—Aggregates of roughly cubic shape, but often with irregular sides and edges; 0.5" to 4" in diameter. Found in heavy lacustrine clays and in the A horizons of brown and dark brown soils.

Nutty.—Hard, well defined cubic aggregates, often with more or less rounded corners. 0.2" to 0.5" in diameter. Found in B horizon of solonetzic and degraded black soils.

Granular.—Cubic aggregates with more or less rounded form. 0.2" to less than 0.1" in diameter. Found in A horizons of non-solonetzic grassland soils, and also formed by crushing the clods and columns in the subsoils of these profiles.

Fragmental.—Hard, nut-sized aggregates with sharp angular corners. Found in the B_1 horizons of leached soils, solodized-solonetz and podzolic profiles.

2.—**Columnar Structures.**—Soil aggregates arranged in vertical columns which are of greater length than the horizontal dimensions. Vertical length 2" to 8" or more; diameter 1" to 4".

Hard Columnar.—Firm, well defined column with smooth hard sides. Forms the B_1 horizon of the dominant grassland soils.

Round-topped Columnar.—Hard, well defined column with rounded top, the latter dusted with white particles. Forms the B_1 horizon of the solodized-solonetz profile.

Irregular Columnar.—Less firm and hard than the above, with rough, irregularly shaped sides, and separating into rough cloddy aggregates. Found in the B horizons of slightly degraded black soils.

3.—**Platy Structures.**—Soil arranged in horizontal plate-like aggregates, the horizontal dimensions being greater than the vertical.

Platy.—Platy or foliated aggregates, above 2" to less than 0.05" thick (vertical dimension). Found in leached A horizons of solonetzic, degraded black and podzolic soils. The thicker plates often consist of numerous thin platy or foliated aggregates joined together.

Laminated.—Thin horizontal bedding of uniform material. This term is used to describe the appearance of glacial alluvial, lacustrine and resorted boulder clay deposits forming the parent materials of various soils. The lower B horizon of such soils is also sometimes described as being faintly laminated. It would appear that the laminated condition is related to the original mode of deposition and is not a structural condition developed by soil forming factors.

Banded.—Thick horizontal bedding of mixed materials, from about one-quarter to several inches thick. Thus alternating dark and light coloured bands may be observed in some of the glacial lake deposits. Thin, often wavy, bands are referred to as varves. As with the laminated condition, banded structures are "inherited" from the original geological deposit, and do not represent the processes of soil formation.

4.—**Compound Structures.**—These refer to a combination of two established types of structure in the same soil aggregate or to horizons made up of two or more structural types.

Blocky-Columnar.—Large blocky aggregates with verticle cleavage, and hence tending to separate into columns.

Cloddy-Granular.—Mixed cloddy to granular sized aggregates; very common in grassland clays and in many black soil profiles.

Cloddy-Platy.—Cloddy aggregates with thin platy development showing within individual clods. Found in the A horizons of degraded black and solonetzic soils.

Granular-Platy.—Mixed granular and platy structures as in the A horizon of slightly degraded black soils.

Cloddy-Columnar.—Columnar aggregates breaking into flat-topped segments or clods. Found in solod profile.

5.—**Structureless and Structure not well defined.**—

Single-Grain or Structureless.—Loose, incoherent individual particles, as in loose sand, dune sands or gravel.

Massive or Amorphous.—A large mass of soil with no definite structural form. Found in the lower B and in the C horizons of many Saskatchewan soils, including those on boulder clay.

TABLE 26.—IMPORTANT SPECIES OF PLANTS OF THE SURVEYED AREA

Formation and Type	*Common Name*	*Botanical Name*
GRASSLAND FORMATION	Northern wheatgrass	*Agropyron dasystachyum*
	Slender wheatgrass	*Agropyron pauciflorum*
Parkland Prairie Type	Awned wheatgrass	*Agropyron subsecundum*
	Hooker's oatgrass	*Avena Hookeri*
	Rough fescue	*Festuca scabrella*
	June grass	*Koeleria cristata*
	Mat Muhly	*Muhlenbergia squarrosa*
	Short-awned porcupine grass	*Stipa spartea, var. curtiseta*
	Involute-leaved sedge	*Carex Eleocharis*
	Sun-loving sedge	*Carex heliophila*
	Mouse-ear chickweed	*Cerastium campestre*
	Anemone	*Anemone canadensis*
	Prairie anemone	*Pulsatilla ludoviciana*
	Alum root	*Heuchera Richardsonii*
	Strawberry	*Fragaria glauca*
	Cinquefoil	*Potentilla spp.*
	Prairie Rose	*Rosa alcea*
	Three-flowered avens	*Sieversia ciliata*
	Purple milk vetch	*Astragalus goniatus*
	American hedysarum	*Hedysarum americanum*
	Golden pea	*Thermopsis rhombifolia*
	Narrow-leaved vetch	*Vicia sparsifolia*
	Golden meadow parsnip	*Zizia cordata*
	Wolf willow	*Elaeagnus commutata*
	Northern bedstraw	*Galium boreale*
	Western snowberry	*Symphoricarpos occidentalis*
	Bastard toad flax	*Comandra pallida*
	Wooly yarrow	*Achillea lanulosa*
	Small-leaved pussy-paws	*Antennaria microphylla*
	White heath aster	*Aster ericoides*
	Smooth aster	*Aster laevis*
	Smooth goldenrod	*Solidago glaberrima*
Parkland:	Awned wheatgrass	*Agropyron subsecundum*
Wooded Type	Fringed brome	*Bromus ciliatus*
	Hoary wild rye	*Elymus innovatus*
	White-grained mountain rice	*Oryzopsis asperifolia*
	False bromegrass	*Schizachne purpurescens*
	Sprengel's sedge	*Carex Sprengelii*
	Small-flowered Solomon's seal	*Smilacina stellata*
	Balsam poplar	*Populus tacamahacca*
	Aspen	*Populus tremuloides*
	Beaked willow	*Salix Bebbiana, var. perostrata*
	Pussy willow	*Salix discolor*
	Basket willow	*Salix petiolaris*
	White baneberry	*Actaea alba*
	Red baneberry	*Actaea rubra*
	Barly meadow-rue	*Thalictrum dioicum*
	Northern gooseberry	*Grossularia oxyacanthoides*

TABLE 26.—(Continued)

Formation and Type	Common Name	Botanical Name
	Saskatoon berry	*Amelanchier alnifolia*
	Strawberry	*Fragaria glauca*
	Black-fruited chokecherry	*Prunus melanocarpa*
	Prickly rose	*Rosa acicularis*
	Wood's rose	*Rosa Woodsii*
	Cream-colored pea-vine	*Lathyrus ochroleucus*
	Wild pea-vine	*Lathyrus venosus*
	American vetch	*Vicia americana*
	Low buffalo-berry	*Shepherdia canadensis*
	Wild sarsaparilla	*Aralia nudicaulis*
	Bunchberry	*Chamaepericlimenum canadense*
	River-bank dogwood	*Svida instolonea*
	Twining honeysuckle	*Lonicera glaucescens*
	Few-flowered snowberry	*Symphoricarpos pauciflorus*
	Smooth aster	*Aster laevis*
	Lindley's aster	*Aster Lindleyanus*
FOREST FORMATION	Balsam fir	*Abies balsamea*
	Larch, tamarack	*Larix laricina*
Mixedwood Section	White spruce	*Picea glauca*
	Black spruce	*Picea mariana*
	Jack pine	*Pinus Banksiana*
	Sprengel's sedge	*Carex Sprengelii*
	Balsam poplar	*Populus tacamahacca*
	Aspen	*Populus tremuloides*
	Willows	*Salix spp.*
	Common alder	*Alnus incana*
	Paper birch	*Betula papyrifera*
	Beaked hazelnut	*Corulus rostrata*
	Northern gooseberry	*Grossularia oxyacanthoides*
	Wild black currant	*Ribes americanum*
	Northern black currant	*Ribes hudsonianum*
	American wood strawberry	*Fragaria americana*
	Wild red raspberry	*Rubus melanolasius*
	Dewberry	*Rubus pubescens*
	Early blue violet	*Viola adunca*
	Canada violet	*Viola canadensis*
	Fireweed	*Chamaenerion spicatum*
	Cow parsnip	*Hieracleum lanatum*
	Liver-leaf wintergreen	*Pyrola asarifolia*
	Tall mertensia	*Mertensia paniculata*
	Swamp honeysuckle	*Distegia involucrata*
	Twinflower	*Linnaea americana*
	Twining honeysuckle	*Lonicera glaucescens*
	Low-brush cranberry	*Viburnum eradiatum*
	High-bush cranberry	*Viburnum trilobum*
	Showy aster	*Aster conspicuus*
	Lindley's aster	*Aster Lindleyanus*
IMPORTANT LOCAL COMMUNITIES	Jack pine	*Pinus Banksiana*
	Sheep fescue	*Festuca ovina*
	June grass	*Koeleria cristata*
Forest Sands (acid)	Slender mountain rice	*Oryzopsis pungens*
	Bearberry	*Arctostaphylos Uva-ursi*
	Blueberry	*Cyanococcus canadensis*
	Sand cranberry	*Vaccinium Vitis-idaea*
	Long-leaved bluets	*Houstonia longifolia*
	Pussy-paws	*Entennaria spp.*

TABLE 26.—(Continued)

Formation and Type	Common Name	Botanical Name
Meadow-Marsh Areas	Cat tail	*Typha latifolia*
	Marsh reedgrass	*Calamogrostis canadensis*
	Northern reedgrass	*Calamogrostis inexpansa*
	Spangle top	*Fluminea festucacea*
	Manna grasses	*Glyceria spp.*
	Reed canary grass	*Phalaris arundinacea*
	Tall reedgrass	*Phragmites communis*
	Fowl bluegrass	*Poa palustris*
	Awned sedge	*Carex atherodes*
	Graceful sedge	*Carex praegracilis*
	Beaked sedge	*Carex rostrata*
	Creeping spike-rush	*Eleocharis palustris*
	Great bulrush	*Scirpus validus*
	Baltic rush	*Juncus ater*
	Basket willow	*Salix petiolaris*
	Meadow knotweed	*Persicaria pratincola*
	Water crowfoot	*Batrachium trichophyllum*
	Seaside crowfoot	*Halerpestes Cymbalaria*
Bog and Muskeg Areas	Sphagnum moss	*Sphagnum spp.*
	Larch, tamarack	*Larix laricina*
	Black spruce	*Picea mariana*
	Sedges	*Carex spp.*
	Cotton grass	*Eriophorum spp.*
	Willows	*Salix spp.*
	Swamp birch	*Betula glandulosa*
	Shrubby cinquefoil	*Dasiphora fruticosa*
	Labrador tea	*Ledum groenlandicum*

Note. Botanical names in the above list are according to Rydberg, P.A., 1932. Flora of the Prairies and Plains of Central North America.

TABLE 27.—APPROXIMATE ACREAGES OCCUPIED BY SOIL ASSOCIATIONS, MISCELLANEOUS AND TOPOGRAPHICAL PHASES

	Level to Undulating	Mixed Undulating and Gently Rolling and Roughly Undulating	Gently to Moderately Rolling	Strongly Rolling to Hilly	Total Area	Per cent. of Area Surveyed
Black Soils						
Oxbow	9,300	6,200	1,400	9,800	26,700	0.42
Waseca	98,500	107,450	78,350	76,200	360,500	5.70
Lloydminster	6,100	5,850	—	—	11,950	0.19
Onion Lake	7,550	3,550	7,300	3,350	21,750	0.35
Whitesand	126,900	49,250	18,200	10,350	204,700	3.24
Meota	20,750	5,000	27,650	3,150	56,550	0.89
Blaine Lake	22,100	15,850	12,250	—	50,200	0.79
Canora	2,950	—	—	—	2,950	0.05
Meadow Lake	56,350	1,900	—	—	58,250	0.92
Total	351,000	195,050	145,150	102,850	794,050	12.55
Degraded Black Soils						
Whitewood	276,000	130,750	150,600	15,600	572,950	9.06
Horsehead	50,300	10,650	4,250	—	65,200	1.03
Makwa	65,900	4,250	1,000	—	71,150	1.12

TABLE 27.—(Continued)

	Level to Undulating	Mixed Undulating and Gently Rolling and Roughly Undulating	Gently to Moderately Rolling	Strongly Rolling to Hilly	Total Area	Per cent. of Area Surveyed
Pelly	73,300	38,300	3,900	—	115,500	1.82
Kelsey	53,150	—	—	—	53,150	0.84
Glenbush	88,800	18,250	34,050	19,400	160,500	2.54
Shellbrook	149,400	57,350	36,600	6,050	249,400	3.94
Whitefox	53,850	—	—	—	53,850	0.85
Nipawin	42,300	3,150	4,300	—	49,750	0.79
Kamsack	84,250	23,800	11,200	—	119,250	1.89
Tisdale	121,250	—	—	—	121,250	1.92
Beaver River	36,050	—	—	—	36,050	0.57
Total	1,094,550	286,500	245,900	41,050	1,668,000	26.37
Wooded Calcareous Soils						
Paddockwood	96,600	19,950	—	—	116,550	1.84
Weirdale	191,750	13,750	1,850	—	207,350	3.28
Carrot River	95,700	—	—	—	95,700	1.51
Total	384,050	33,700	1,850	—	419,600	6.63
Grey and Brownish-Grey Podzol Soils						
Waitville	304,050	186,450	283,200	21,850	795,550	12.58
Loon River	192,850	129,650	66,400	53,350	442,250	6.99
Bodmin	195,600	41,850	47,300	25,900	310,650	4.91
Pine	152,100	50,600	16,500	12,000	231,200	3.66
Sylvania	72,100	6,200	6,000	3,500	87,800	1.38
Aborfield	25,050	—	—	—	25,050	0.40
Garrick	50,650	4,050	—	—	54,700	0.86
Smeaton	37,950	2,500	—	—	40,450	0.64
La Corne	25, 00	17,450	6,750	—	49,600	0.78
Dorintosh	27,100	3,750	1,050	—	31,900	0.50
Total	1,082,850	442,500	427,200	116,600	2,069,150	32.70
Miscellaneous Soils						
Saline (Alkali)	—	—	—	—	700	0.01
Alluvium	—	—	—	—	16,050	0.26
Meadow	—	—	—	—	133,950	2.13
Muskeg	—	—	—	—	155,700	2.47
Meadow-Bog	—	—	—	—	529,700	8.39
Dune Sand	—	—	—	—	14,150	0.22
Undifferentiated Sands	—	—	—	—	16,550	0.26
Eroded	—	—	—	—	255,450	4.04
Unclassified areas	—	—	—	—	251,050	3.98
Total	—	—	—	—	1,372,600	21.75
Total area	2,912,450	957,750	820,100	260,500	6,323,400	
Approximate per cent. of total area	46%	15%	13%	4%	22% (misc.)	100%

TABLE 28.—STATISTICAL DATA ILLUSTRATING THE AGRICULTURAL DEVELOPMENT OF NORTHERN SASKATCHEWAN (1926-1946)*

	1926	1931	1936	1941	1946
Number of Occupied Farms	5,781	9,829	14,161	13,419	11,592
Total Acreage Occupied	1,564,448	2,511,824	3,453,309	4,050,285	3,610,797
Average Acreage of Farm	270.6	255.5	243.8	301.8	311 6
Acreage under Cultivation	470,154	860,136	1,110,830	1,503,006	1,575,352
Acreage under Wheat	248,266	413,323	453,186	433,194	449,768
Acreage under Oats	99,216	179,504	257,763	324,264	346,576
Acreage under Rye	4,348	2,807	4,302	17,657	17,045
Acreage under Barley	11,089	32,301	71,683	114,053	143,937
Acreage under Flax	208	793	249	9,985	3,403
Acreage under Mixed Grains	171	996	1,153	1,712	4,564
Acreage under Hay (includes alfalfa, clover, grasses)	11,751	7,021	42,143	99,542	119,304
Acreage under Potatoes	1,395	3,297	4,608	4,280	2,845
Acreage under Other Crops	854	13,838	370	283	5,883
Acreage under Pasture:					
Cultivated	4,716	19,606	37,975	73,563	80,702
Native	729,841	1,141,863	1,092,806	1,931.238	1,629,538
Summerfallow	77,864	158,225	217,879	436,242	398,752
Acreage under Woodland	364,453	604,780	1,248,503	616,041	398,696
Number of Horses	—	44,125	56,553	62,938	49,714
Number of Cattle	—	73,215	123,944	105,739	125,321
Number of Sheep	—	9,921	15,317	22,639	27,716
Number of Swine	—	47,467	50,788	118,811	64,707
Number of Poultry	—	527,649	562,422	789,635	782,724

*Secretary of Statistics, Province of Saskatchewan.

TABLE 29.—CENSUS DATA SHOWING GROWTH OF RURAL AND URBAN POPULATION IN NORTHERN SASKATCHEWAN*

	1901	1911	1921	1931	1941	1946
Total Population	12,173	23,820	39,054	66,881	76,735	66,366
Total Rural	10,388	16,927	29,987	52,212	57,098	41,588
Total Urban	1,785	6,893	9,067	14,669	19,637	24,778
Number of Cities	1	1	1	1	1	1
Number of Towns	—	1	1	1	3	3
Number of Villages	—	1	6	14	15	21
Total City Population	1,785	6,254	7,352	9,905	12,508	14,532
Total Town Population	—	441	469	977	3,367	4,802
Total Village Population	—	198	1,246	3,787	3,762	5,444

*Dominion Census.

SOIL MAPS

SASKATCHEWAN SOIL SURVEY

Report No. 13

SASKATCHEWAN SOIL MAPS

SOIL SURVEY OF BI

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SOIL SURVEY REPO

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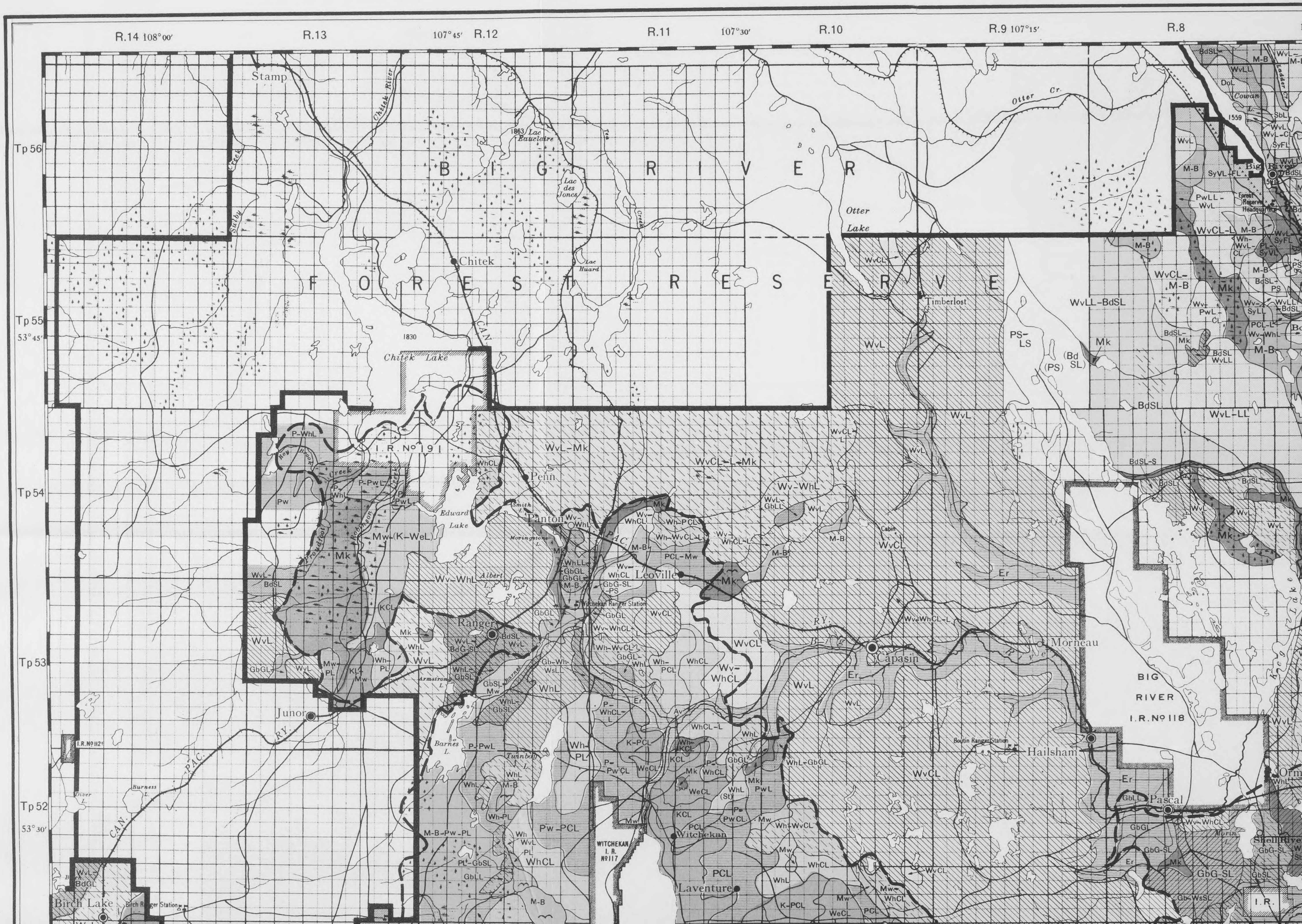

F BIG RIVER SHEET

SASKATCHEWAN

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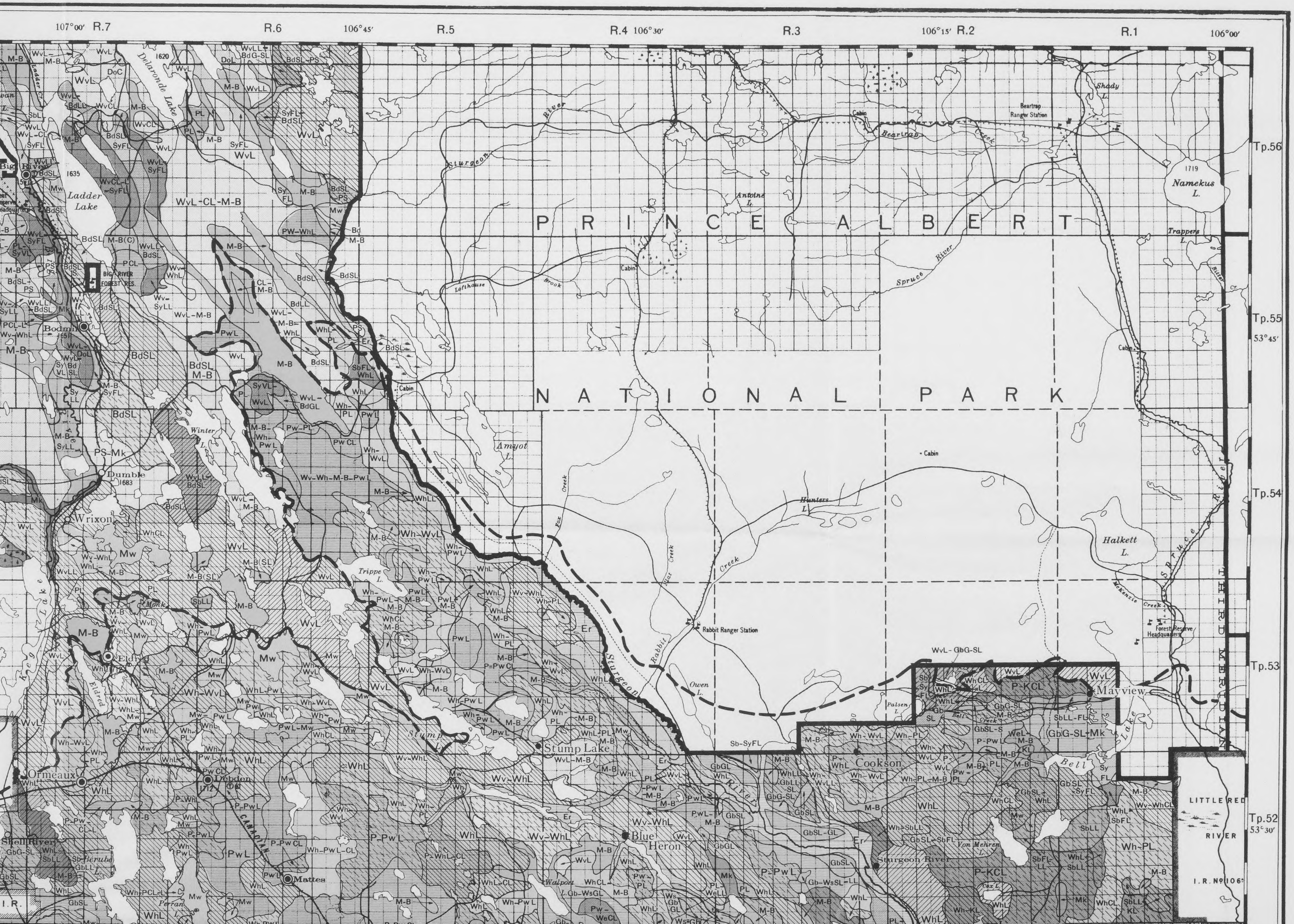

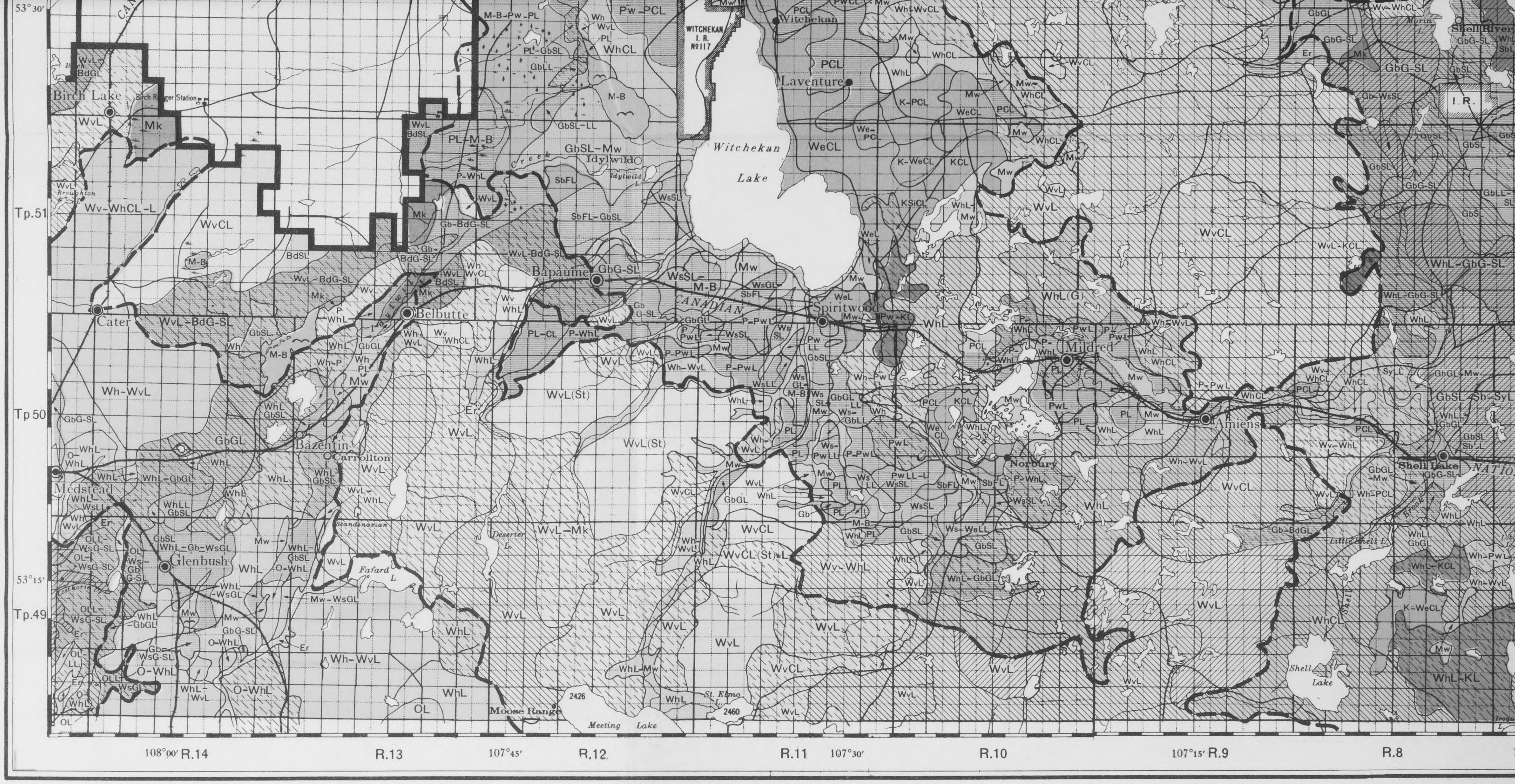

Soil mapping, classification and topography, by the Saskatchewan Soil Survey, which is jointly supported by the University of Saskatchewan, the Provincial Department of Agriculture and the Dominion Experimental Farms Service.

LEGEND

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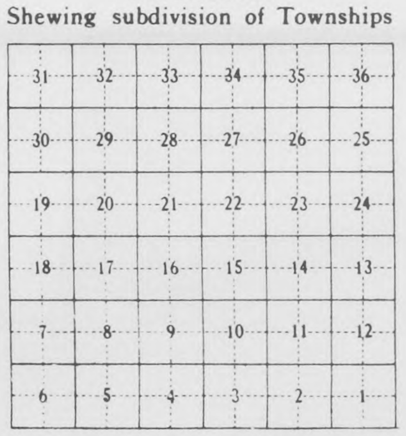
DIAGRAM
Shewing subdivision of Townships



TOPOGRAPHY

Flat to depressional

Very gently sloping to gently and moderately undulating

Areas of mixed undulating and rolling topography; also used for roughly undulating topography

Gently to moderately rolling

Strongly rolling to hilly topography, (may include mixed, moderately and strongly rolling)

Dune topography

Edge of escarpment or terrace

Butte or small isolated hill

STONY AND GRAVELLY CLASSES

Excessively stony, too stony to cultivate .... St

Very stony; serious handicap to cultivation .... (St)

Gravelly — frequent gravelly subsoils .... (G)

SOIL TEXTURES

Heavy Clay	HvC
Clay	C
Silty Clay	SiC
Silty Clay Loam	SiCL
Clay Loam	CL
Sandy Clay Loam	SCL
Silty Loam	SiL
Loam	L
Light Loam	LL
Very Fine Sandy Loam	VL
Fine Sandy Loam	FL
Gravelly Loam	GL
Mixed Gravelly Loam and Sandy Loam	G-SL
Sandy Loam	SL
Loamy Sand	LS
Sand	S
Fine Sandy Loam over Clay Subsoil	FL/C
Light Loam over Clay Subsoil	LL/C

BLACK SOIL ASSOCIATIONS

• Oxbow — Black loam and clay loam on undifferentiated boulder clay (glacial till), chiefly morainic deposits	O
Waseca — Black solonetzic loam to clay loam on morainic boulder clay overlying Cretaceous bedrock	Wa
Lloydminster — Thick black solonetzic loam on modified (resorted) boulder clay over Cretaceous bedrock	Ly
Onion Lake — Black solodized loam to clay loam on modified Cretaceous bedrock	On
Onion Lake — Black solodized clay — heavy clay on modified Cretaceous bedrock	On
• Whitesand — Black gravelly-coarse sandy loam on glacio-fluvial deposits. (Outwash, kames and stream-eroded till)	Ws
• Meota — Black fine sandy loam to sandy light loam on sandy alluvial-lacustrine deposits	Me
• Blaine Lake — Black loam to silty clay loam on silty glacial lacustrine deposits	B
Canora — Thick black highly calcareous loam to silty clay loam on silty glacial lacustrine deposits	Ca
Meadow Lake — Thick black solonetzic clay loam and loam on silty clay glacial lacustrine deposits	Md

• Whitewo

Horsehe

Makwa

• Pelly —

Kelsey –

• Glenbus

• Shellbro

Whitefo

Nipawin

• Kamsac

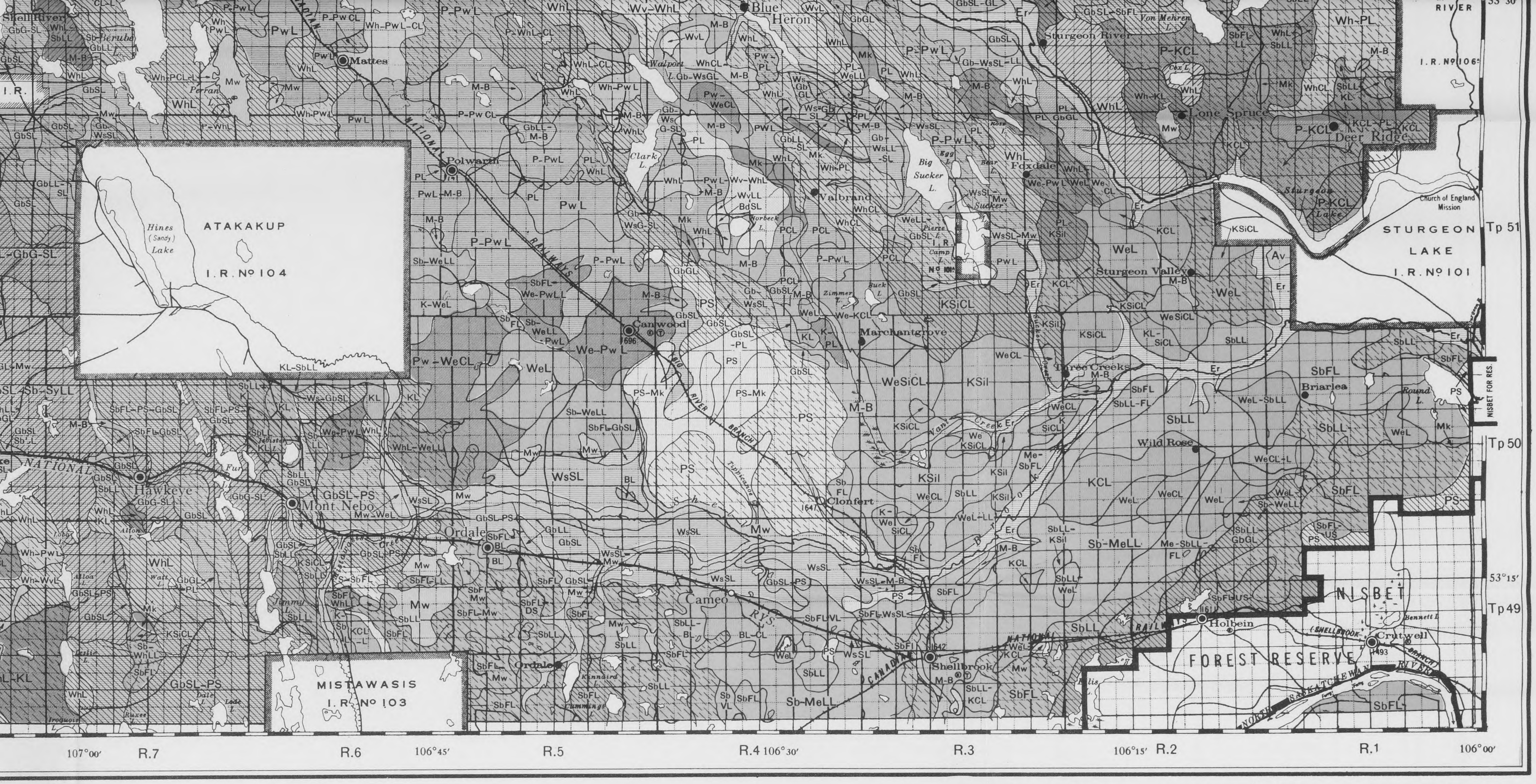
• Kamsac
Tisdale -

Tisdale -
Beaver R

• Paddock

• Weirdale

• Weirdale
Carrot R



Compiled, drawn and published by the Experimental Farms Service, Ottawa, 1950, from base maps supplied by the Hydrographic and Map Service, Department of Mines and Resources, Ottawa.

GEND

BLACK-GREY (DEGRADED BLACK AND WOODED CALCAREOUS) ASSOCIATIONS

(Degraded Black soils)

* Whitewood — Degraded loam to clay loam on undifferentiated boulder clay, chiefly morainic deposits.	Wh
Horsehead — Degraded loam to clay loam on relatively low-lime boulder clay, chiefly morainic.	Ho
Makwa — Chiefly slightly degraded loam to clay loam on highly modified boulder clay, in part associated with glacial lake deposition.	Ma
* Pelly — Chiefly slightly degraded loam to clay loam on modified boulder clay.	P
Kelsey — Degraded and slightly degraded loam to clay loam on lake modified boulder clay.	Ky
* Glenbush — Degraded gravelly-coarse sandy loams on glacio-fluvial deposits (outwash, kames and stream-eroded till).	Gb
* Shellbrook — Chiefly slightly degraded fine sandy loam to sandy light loam on sandy alluvial-lacustrine deposits.	Sb
Whitefox — Degraded fine to very fine sandy loam on alluvial sandy deposits.	Wf
Nipawin — Degraded loam to clay loam on alluvial very fine sandy-silty deposits.	Np
* Kamsack — Slightly degraded and degraded loam to silty clay loam on silty glacial lacustrine deposits.	K
* Kamsack — Clay and silty clay types of Kamsack soils.	K
Tisdale — Slightly degraded silty clay loam and clay loam on silty clay glacial lacustrine deposits.	Ti
Tisdale — Heavy clay types of Tisdale soils.	Ti
Beaver River — Degraded clay loam-loam on silty clay glacial lacustrine deposits.	Bv

(Wooded Calcareous Soils)

* Paddockwood — Calcareous (very limy) loam to clay loam on modified boulder clay.	Pw
* Weirdale — Calcareous loam to silty clay loam on silty glacial lacustrine deposits.	We
* Weirdale — Clay and silty clay types of Weirdale soils.	We
Carrot River — Calcareous fine sandy loam to very fine sandy loam and sandy light loam on alluvial sandy deposits. (Originally peaty surface).	Cr

GREY AND BROWNISH-GREY PODZOL ASSOCIATIONS

* Waitville — Grey loam to clay loam on undifferentiated boulder clay, chiefly morainic deposits.	Wv
Loon River — Grey loam to clay loam on relatively low-lime boulder clay, chiefly morainic.	Ln
* Bodmin — Grey gravelly-coarse sandy loams on glacio-fluvial deposits (outwash, kames and stream-eroded till).	Bd
* Pine Sand — Grey sands and loamy sands on alluvial-aeolian fine sands.	PS
* Sylvania — Grey fine sandy loam and very fine sandy loam to sandy light loam on sandy alluvial-lacustrine deposits.	Sy
Arborfield — Chiefly grey podzol-solonetzic clay and heavy clay on clay glacial lacustrine deposits.	Ar
Garrick — Grey and brownish-grey loam and clay loam on lake modified boulder clay.	Ga
Smeaton — Brownish-grey and grey gritty loam to sandy loam on shallow glacio-fluvial deposits over lake modified boulder clay.	Sm
La Corne — Brownish-grey fine, and very fine sandy loam to sandy light loam on sandy alluvial deposits. Rolling areas may indicate reworking by wind.	Lc
Dorintosh — Chiefly brownish-grey clay loam and loam on silty glacial lacustrine deposits.	Do

* All soils marked thus occur on the above map.

MISCELLANEOUS SOILS
(Undifferentiated Associations and Complexes)

* Alluvium — Undifferentiated soils on recent alluvial deposits. Frequently poorly drained, but not excessively saline.	Av
Saline (Alkali) — Undifferentiated saline soils, occurring chiefly on poorly drained alluvial and pond deposits.	Sa
* Meadow — Undifferentiated meadow soils on wet alluvial and pond deposits.	Mw
* Muskeg — Undifferentiated bog (peat) soils on recent organic deposits.	Mk
* Meadow-Bog Complex — Mixed areas of meadow, shallow peat and bog soils.	M-B
* Dune Sand — Undifferentiated sands on aeolian dune deposits.	DS
* Undifferentiated Sands — Undifferentiated sand and loamy sand on alluvial-aeolian sand deposits.	US
* Eroded — Eroded soils of valley slopes and escarpments, chiefly thin (truncated) profiles.	Er
Smeaton Complex — Areas of Smeaton soils mixed with one or more of Kelsey, Garrick, Pine, Sylvania and Bodmin Associations.	SmX
Soils on mixed glacial till and lacustrine deposits. e.g.	P-K
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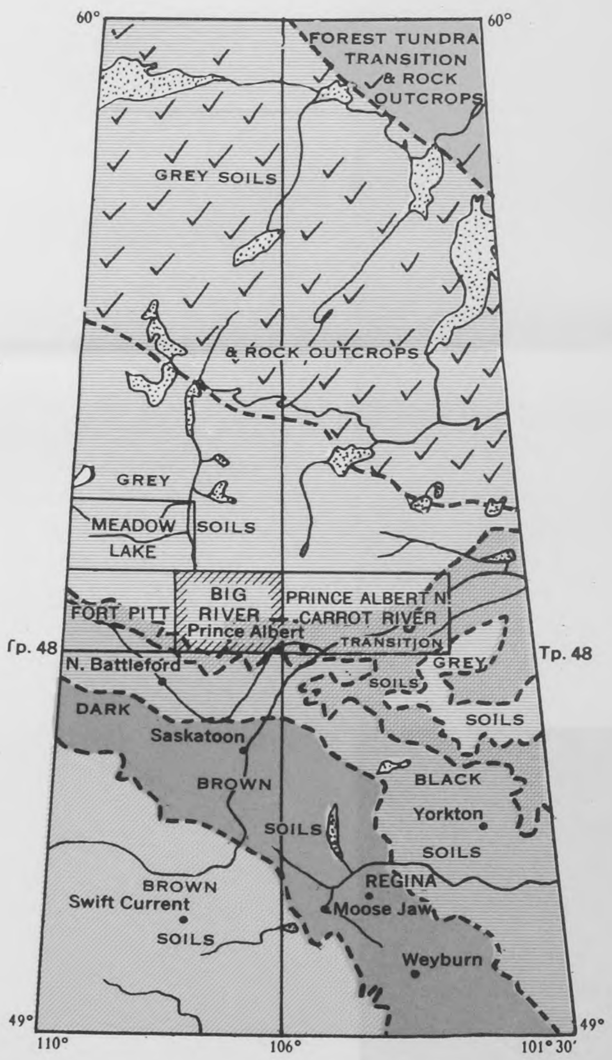
Soils on mixed glacial lacustrine and glacio-fluvial deposits. e.g.	Sb-Gb
Other soil complexes shown by soil symbols and color of dominant or most important soil association. e.g.	Wv-M-B



KEY MAP

SOIL SURVEY OF MI

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SOIL SURVEY

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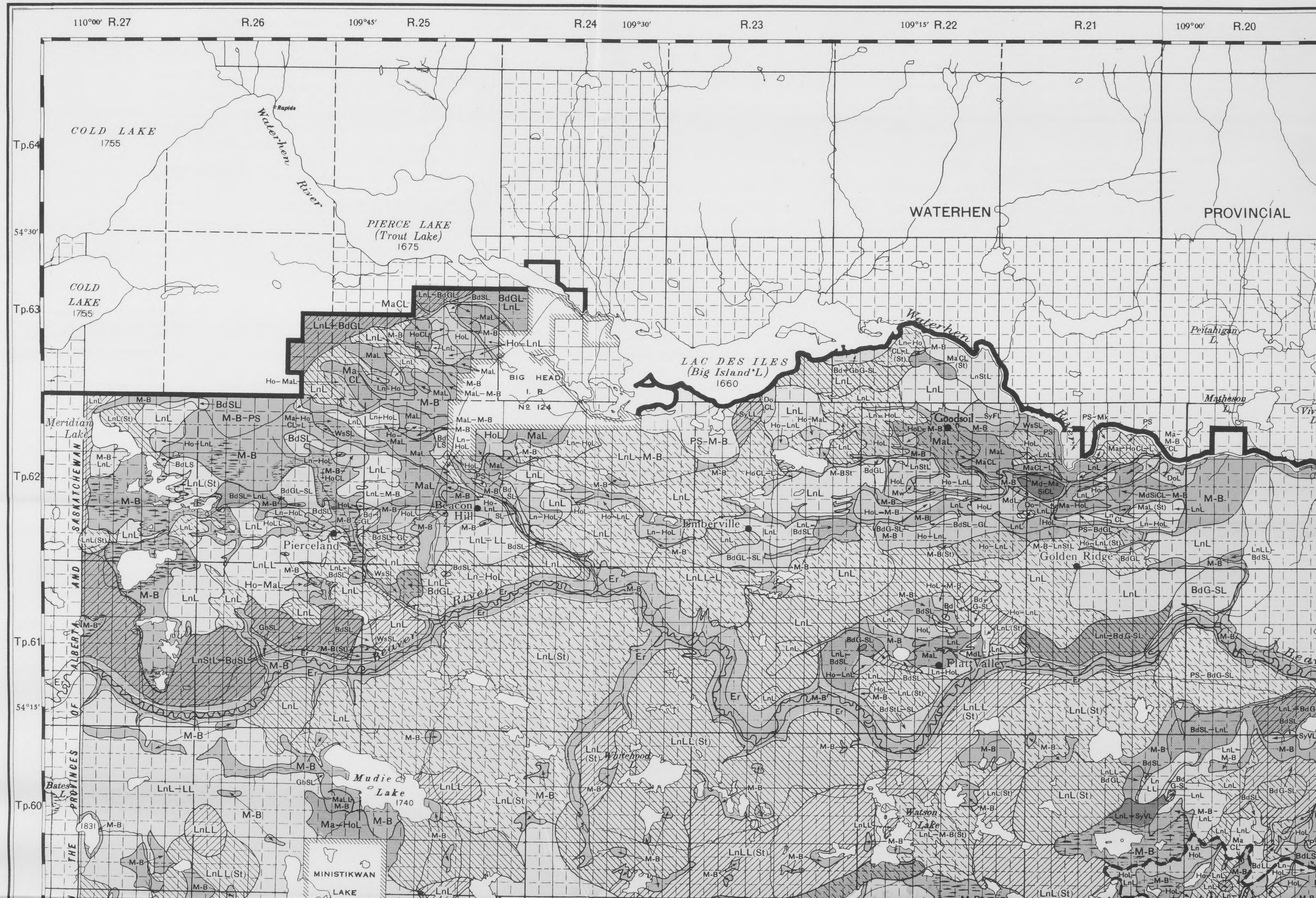

T MEADOW LAKE SHEET

OF SASKATCHEWAN

URVEY REPORT No. 13

Scale 3 miles to 1 inch

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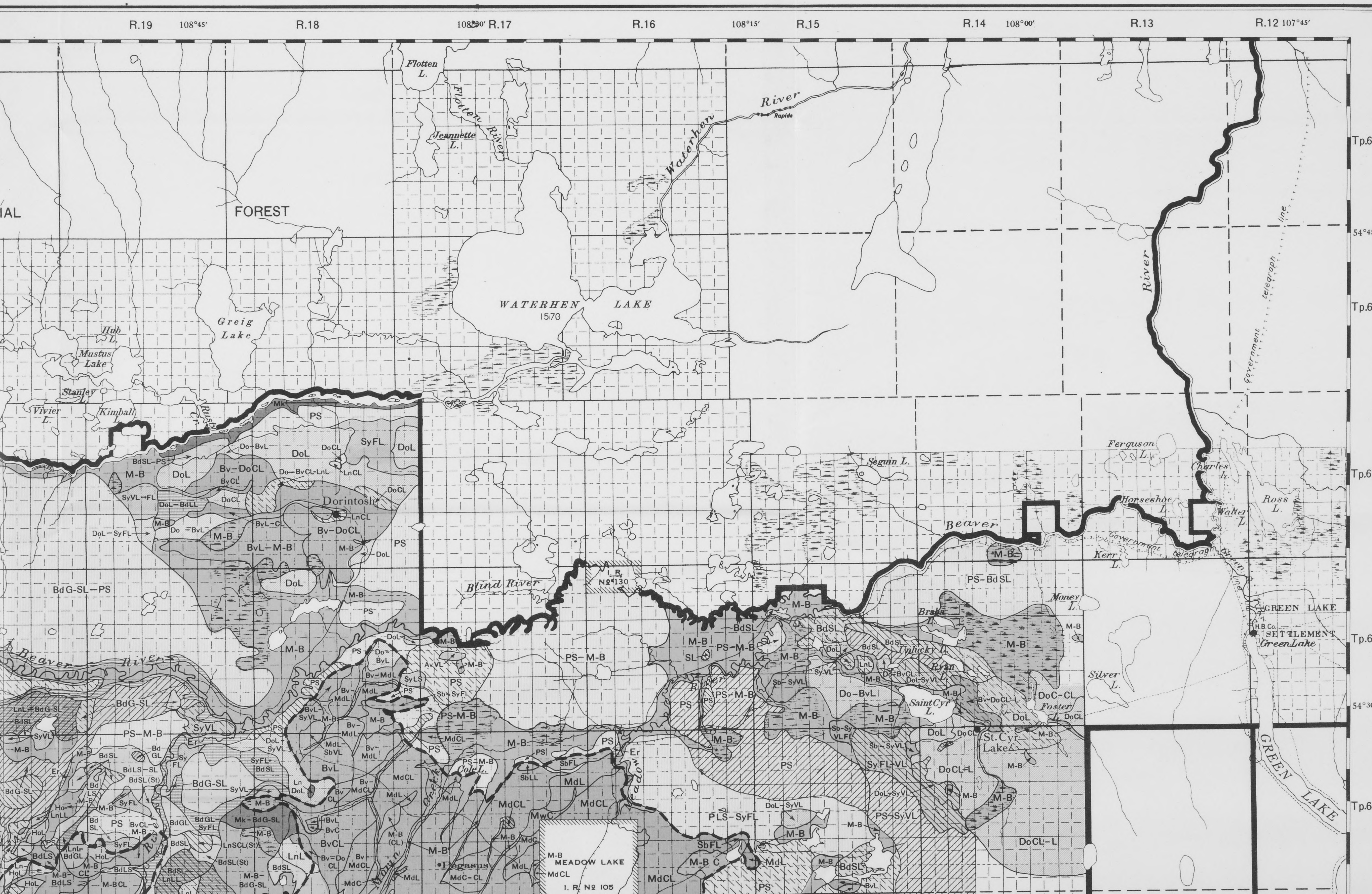

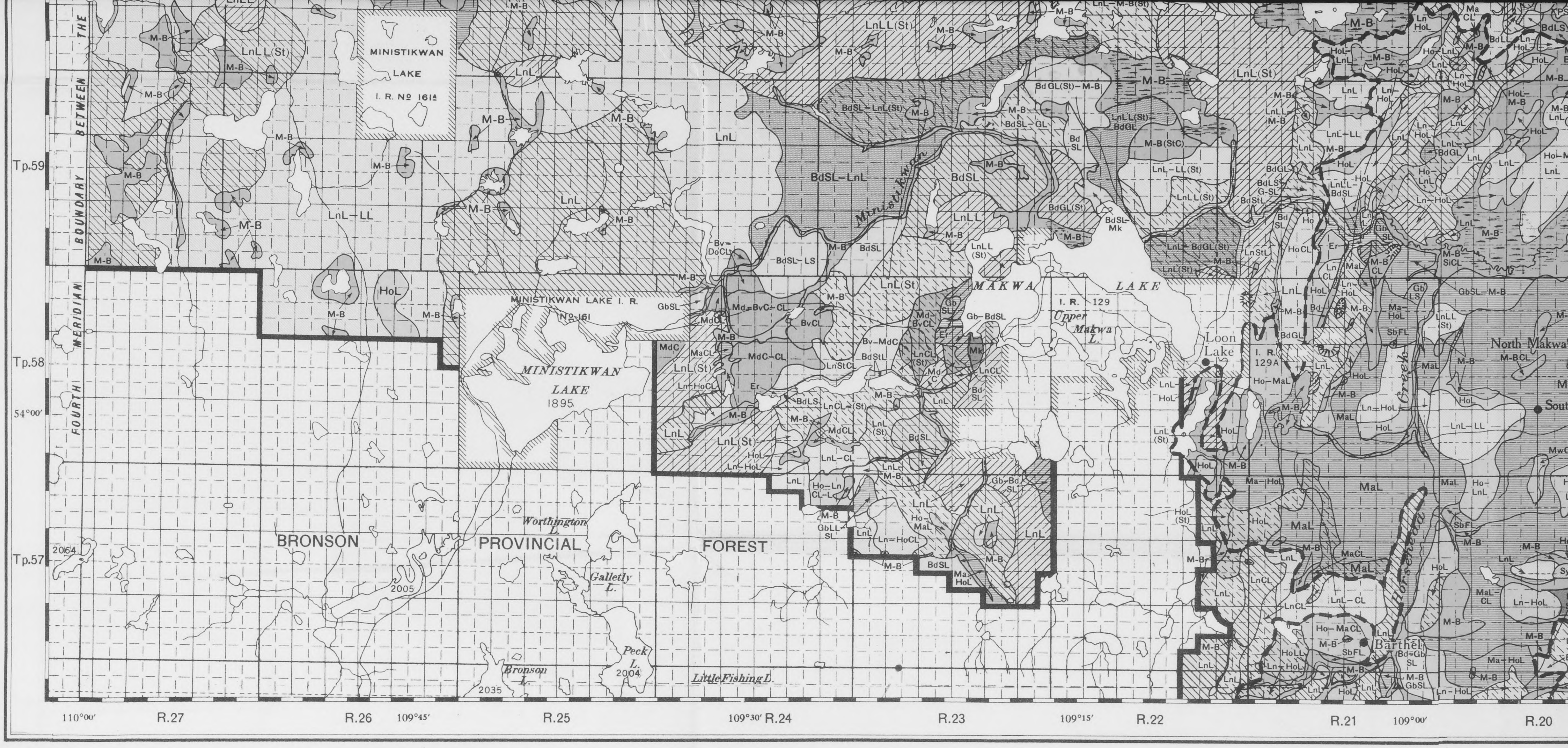

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LEGE

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DIAGRAM

Shewing subdivision of Townships

31	32	33	34	35	36
30	29	28	27	26	25
19	20	21	22	23	24
18	17	16	15	14	13
7	8	9	10	11	12
6	5	4	3	2	1

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Butte or small isolated hill

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Excessively stony, too stony to cultivate — St

Very stony; serious handicap to cultivation — (St)

Gravelly — frequent gravelly subsoils — (G)

OTHER FEATURES

Soil Zone Boundary

Forest Boundary

Indian Reserve

Railway Line and Station

Country Post Office or Rural Centre

Elevation above sea level — 1712′

SOIL TEXTURES

Heavy Clay	HvC
Clay	C
Silty Clay	SiC
Silty Clay Loam	SiCL
Clay Loam	CL
Sandy Clay Loam	SCL
Silty Loam	SiL
Loam	L
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*Horseh

*Makwa

Pelly –

Kelsey

*Glenbu

*Shellbr

Whitef

Nipawi

Kamsa

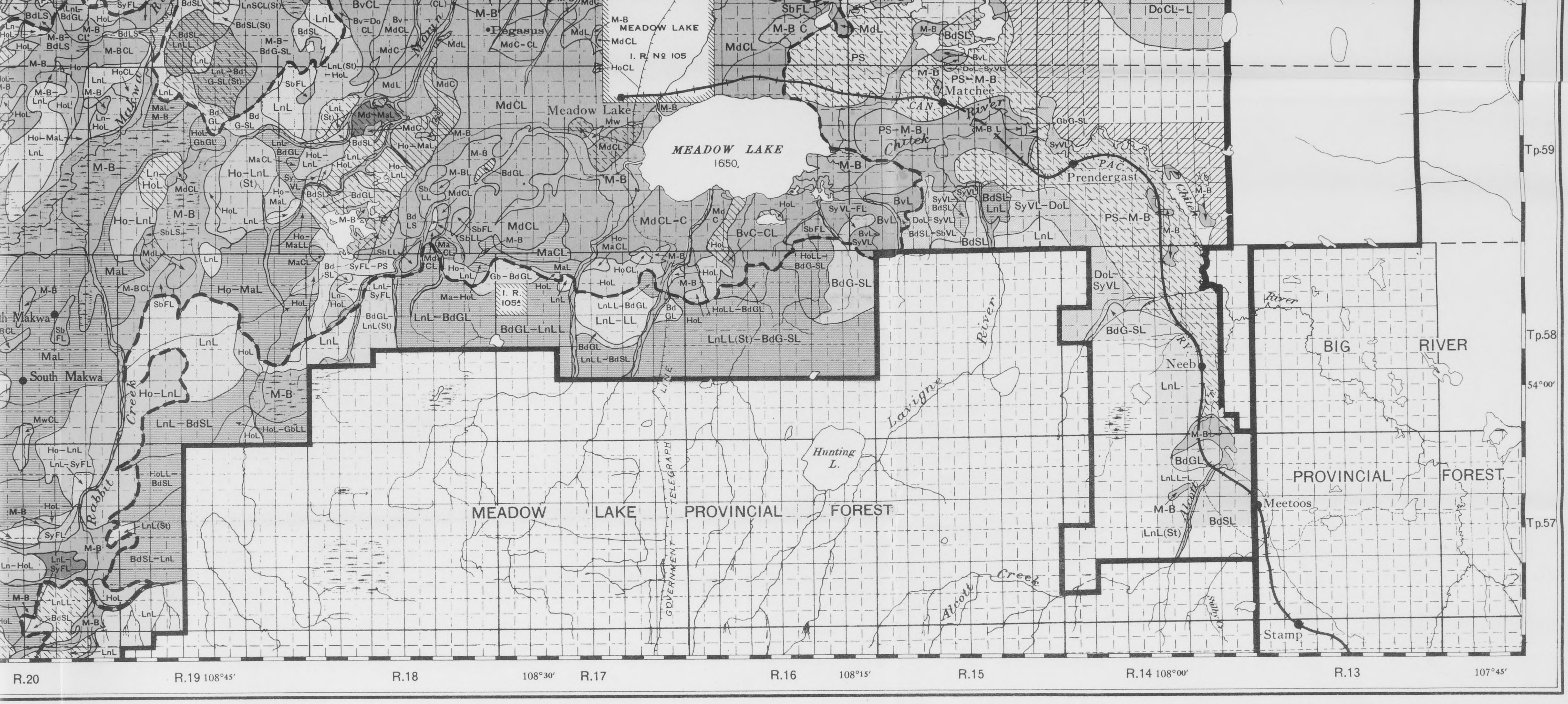
Kamsa
Tisdale

Tisdale
*Beaver

Paddoc

Weirda

Weirda
Carrot



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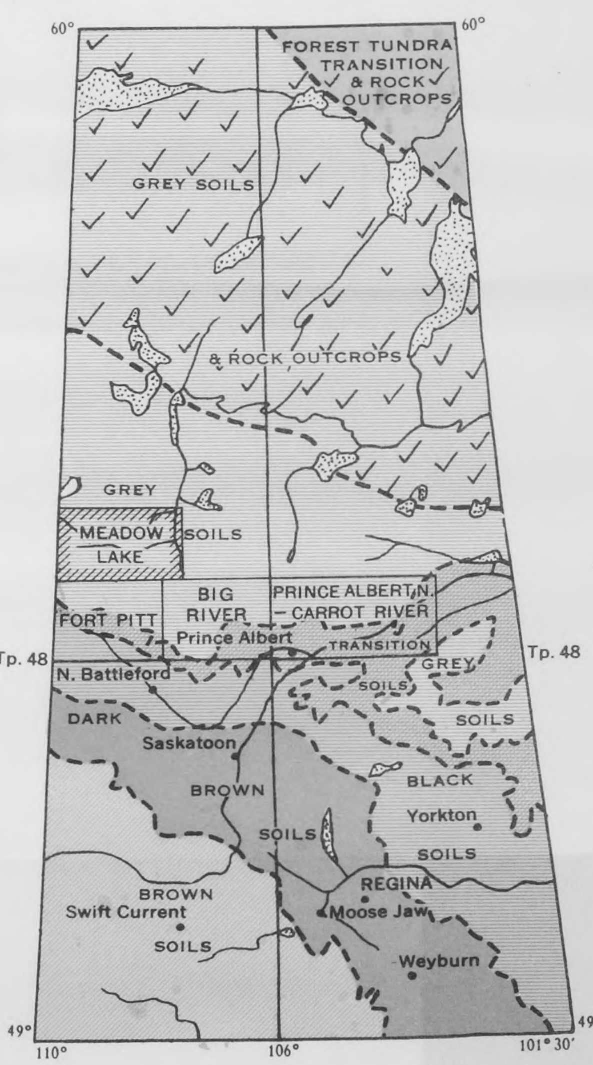

KEY MAP

SOIL SURVEY OF F

PROVINCE OF SAS

SOIL SURVEY REF

Scale 3 miles to

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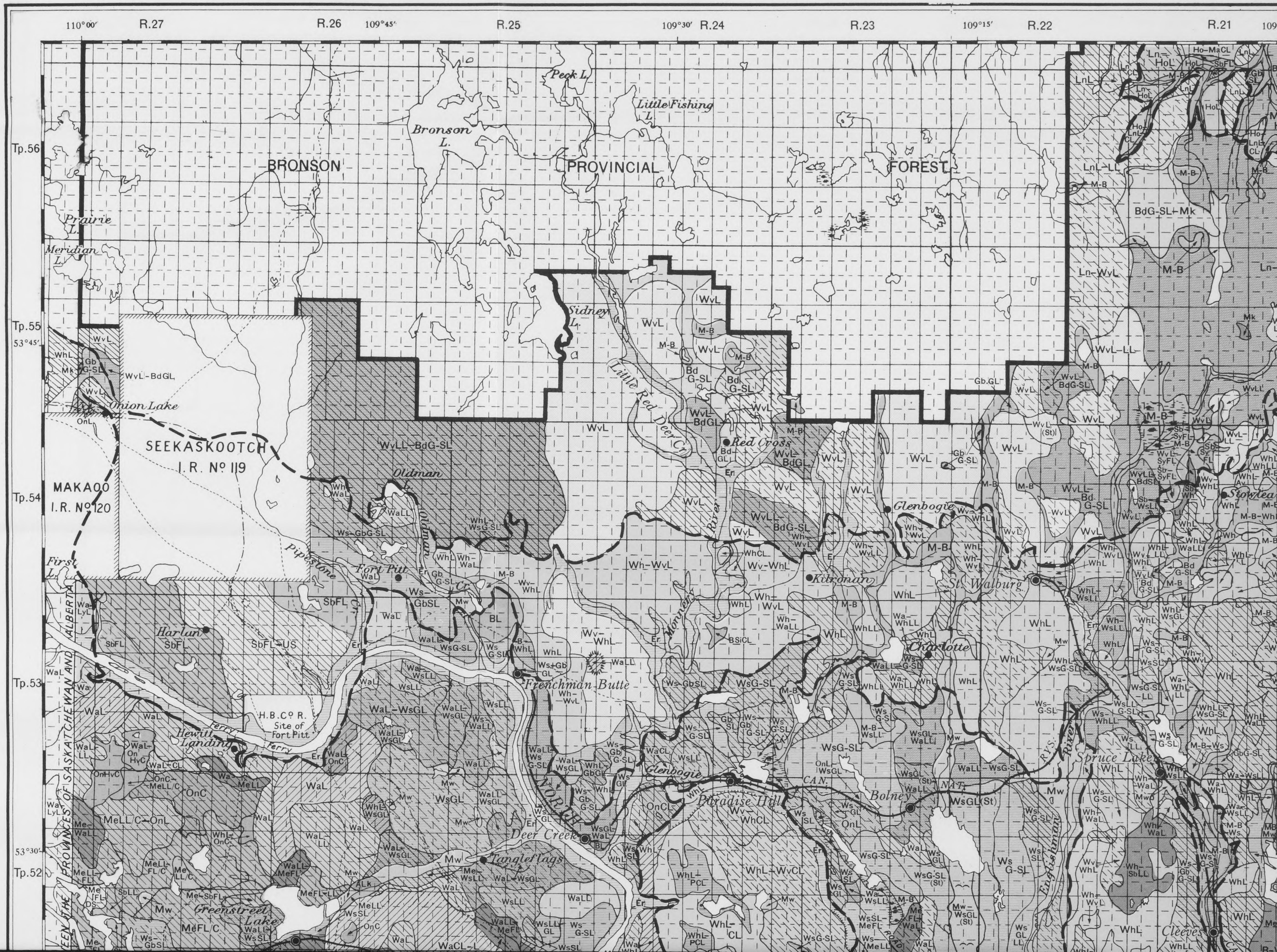

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OF SASKATCHEWAN

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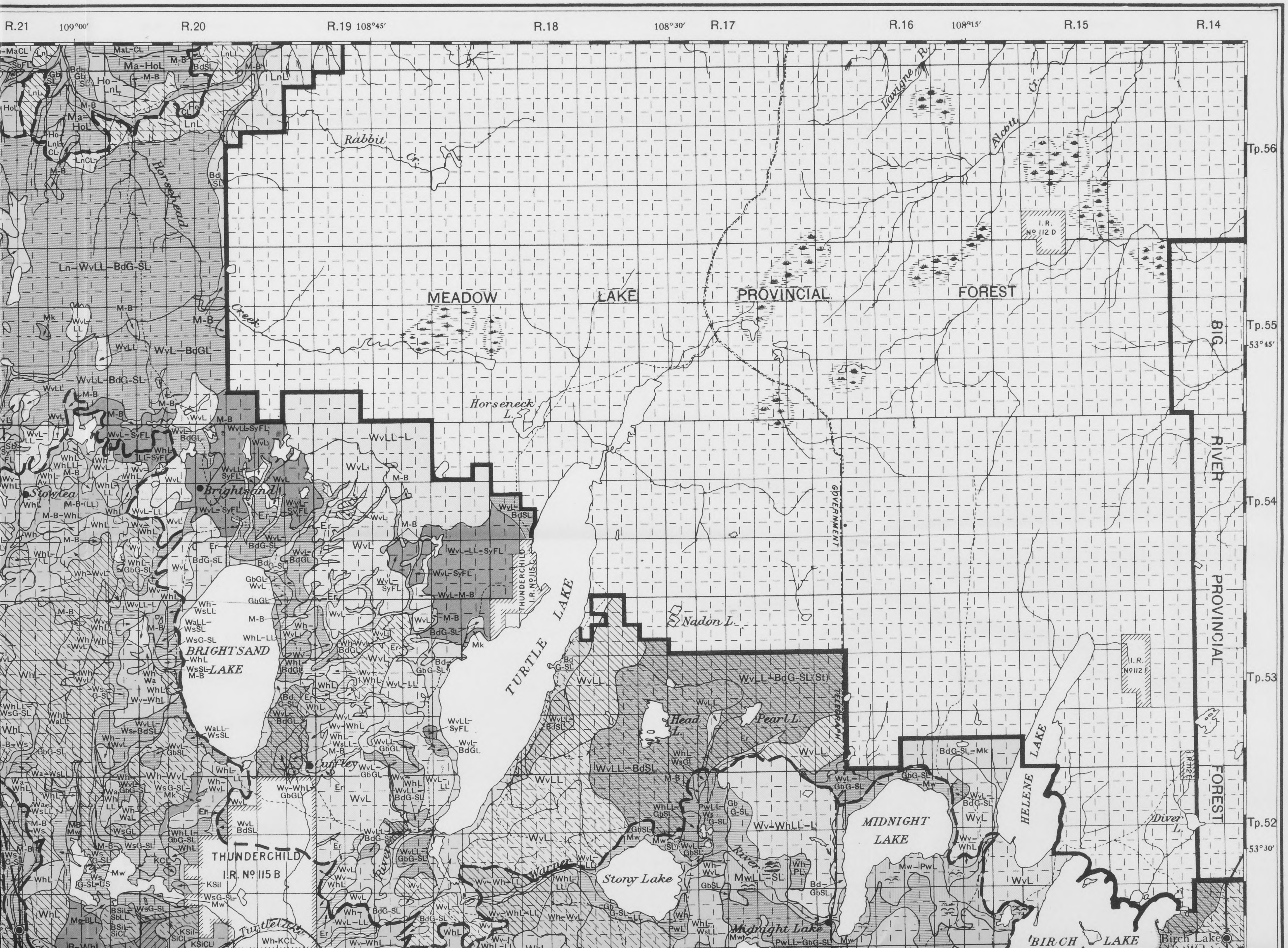

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DIAGRAM
Shewing subdivision of Townships

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19	20	21	22	23	24
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7	8	9	10	11	12
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TOPOGRAPHY

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- Gently to moderately rolling
- Strongly rolling to hilly topography, (may include mixed, moderately and strongly rolling)
- Dune topography
- Edge of escarpment or terrace
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STONY AND GRAVELLY CLASSES

- Excessively stony, too stony to cultivate — St
- Very stony; serious handicap to cultivation — (St)
- Gravelly — frequent gravelly subsoils — (G)

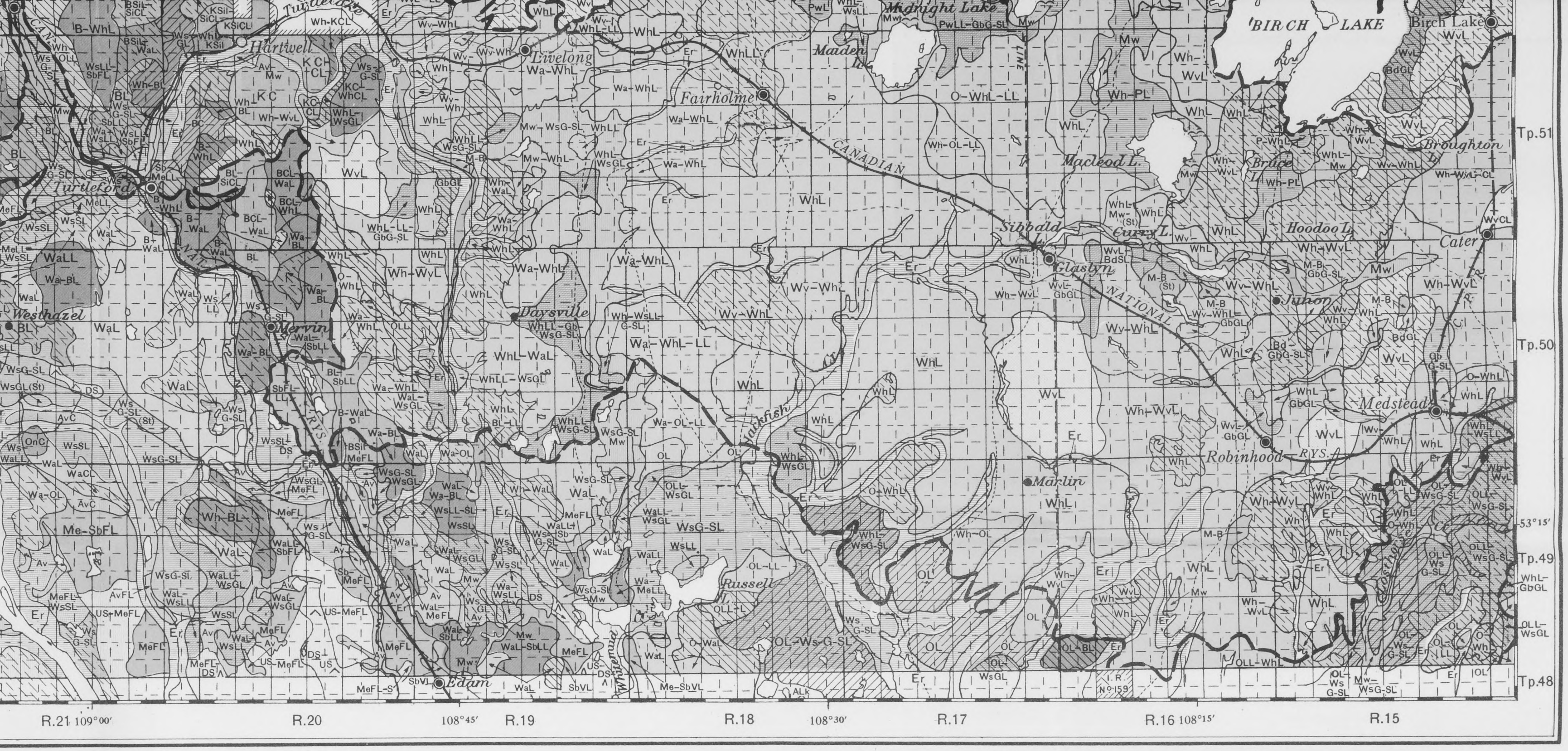
SOIL TEXTURES

Heavy Clay	HvC
Clay	C
Silty Clay	SiC
Silty Clay Loam	SiCL
Clay Loam	CL
Sandy Clay Loam	SCL
Silty Loam	Sil
Loam	L
Light Loam	LL
Very Fine Sandy Loam	VL
Fine Sandy Loam	FL
Gravelly Loam	GL
Mixed Gravelly Loam and Sandy Loam	G-SL
Sandy Loam	SL
Loamy Sand	LS
Sand	S
Fine Sandy Loam over Clay Subsoil	FL/C
Light Loam over Clay Subsoil	LL/C

BLACK SOIL ASSOCIATIONS

- * Oxbow — Black loam and clay loam on undifferentiated boulder clay (glacial till), chiefly morainic deposits — O
- * Waseca — Black solonetzic loam to clay loam on morainic boulder clay overlying Cretaceous bedrock — Wa
- * Lloydminster — Thick black solonetzic loam on modified (resorted) boulder clay over Cretaceous bedrock — Ly
- * Onion Lake — Black solodized loam to clay loam on modified Cretaceous bedrock — On
- * Onion Lake — Black solodized clay — heavy clay on modified Cretaceous bedrock — On
- * Whitesand — Black gravelly-coarse sandy loam on glacio-fluvial deposits. (Outwash, kames and stream-eroded till) — Ws
- * Meota — Black fine sandy loam to sandy light loam on sandy alluvial-lacustrine deposits — Me
- * Blaine Lake — Black loam to silty clay loam on silty glacial lacustrine deposits — B
- Canora — Thick black highly calcareous loam to silty clay loam on silty glacial lacustrine deposits — Ca
- Meadow Lake — Thick black solonetzic clay loam and loam on silty clay glacial lacustrine deposits — Md

* Whitewo
* Horsehe
* Makwa
* Pelly —
Kelsey -
* Glenbus
* Shellbro
Whitefo
Nipawin
* Kamsac
* Kamsac
Tisdale -
Tisdale -
Beaver F
* Paddock
Weirdale
Weirdale
Carrot F



Compiled, drawn and published by the Experimental Farms Service, Ottawa, 1950, from base maps supplied by the Hydrographic and Map Service, Department of Mines and Resources, Ottawa.

LEGEND

BLACK-GREY (DEGRADED BLACK AND WOODED CALCAREOUS) ASSOCIATIONS

(Degraded Black soils)

* Whitewood — Degraded loam to clay loam on undifferentiated boulder clay, chiefly morainic deposits.	Wh
* Horsehead — Degraded loam to clay loam on relatively low-lime boulder clay, chiefly morainic.	Ho
* Makwa — Chiefly slightly degraded loam to clay loam on highly modified boulder clay, in part associated with glacial lake deposition.	Ma
* Pelly — Chiefly slightly degraded loam to clay loam on modified boulder clay.	P
Kelsey — Degraded and slightly degraded loam to clay loam on lake modified boulder clay.	Ky
* Glenbush — Degraded gravelly-coarse sandy loams on glacio-fluvial deposits (outwash, kames and stream-eroded till).	Gb
* Shellbrook — Chiefly slightly degraded fine sandy loam to sandy light loam on sandy alluvial-lacustrine deposits.	Sb
Whitefox — Degraded fine to very fine sandy loam on alluvial sandy deposits.	Wf
Nipawin — Degraded loam to clay loam on alluvial very fine sandy-silty deposits.	Np
* Kamsack — Slightly degraded and degraded loam to silty clay loam on silty glacial lacustrine deposits.	K
* Kamsack — Clay and silty clay types of Kamsack soils.	K
Tisdale — Slightly degraded silty clay loam and clay loam on silty clay glacial lacustrine deposits.	Ti
Tisdale — Heavy clay types of Tisdale soils.	Ti
Beaver River — Degraded clay loam-loam on silty clay glacial lacustrine deposits.	Bv

(Wooded Calcareous Soils)

* Paddockwood — Calcareous (very limy) loam to clay loam on modified boulder clay.	Pw
Weirdale — Calcareous loam to silty clay loam on silty glacial lacustrine deposits.	We
Weirdale — Clay and silty clay types of Weirdale soils.	We
Carrot River — Calcareous fine sandy loam to very fine sandy loam and sandy light loam on alluvial sandy deposits. (Originally peaty surface).	Cr

GREY AND BROWNISH-GREY PODZOL ASSOCIATIONS

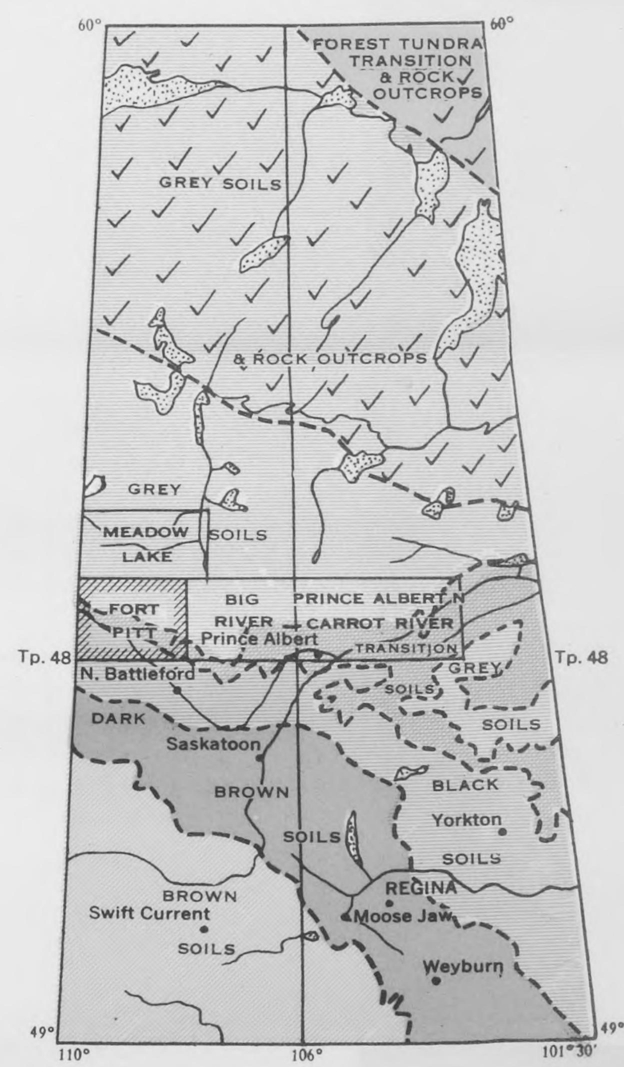
* Waitville — Grey loam to clay loam on undifferentiated boulder clay, chiefly morainic deposits.	Wv
* Loon River — Grey loam to clay loam on relatively low-lime boulder clay, chiefly morainic.	Ln
* Bodmin — Grey gravelly-coarse sandy loams on glacio-fluvial deposits (outwash, kames and stream-eroded till).	Bd
Pine Sand — Grey sands and loamy sands on alluvial-aeolian fine sands.	PS
* Sylvania — Grey fine sandy loam and very fine sandy loam to sandy light loam on sandy alluvial-lacustrine deposits.	Sy
Arborfield — Chiefly grey podzol-solonetzic clay and heavy clay on clay glacial lacustrine deposits.	Ar
Garrick — Grey and brownish-grey loam and clay loam on lake modified boulder clay.	Ga
Smeaton — Brownish-grey and grey gritty loam to sandy loam on shallow glacio-fluvial deposits over lake modified boulder clay.	Sm
La Corne — Brownish-grey fine, and very fine sandy loam to sandy light loam on sandy alluvial deposits. Rolling areas may indicate reworking by wind.	Lc
Dorintosh — Chiefly brownish-grey clay loam and loam on silty glacial lacustrine deposits.	Do

* All soils marked thus occur on the above map.

MISCELLANEOUS SOILS

(Undifferentiated Associations and Complexes)

* Alluvium — Undifferentiated soils on recent alluvial deposits. Frequently poorly drained, but not excessively saline.	Av
* Saline (Alkali) — Undifferentiated saline soils, occurring chiefly on poorly drained alluvial and pond deposits.	Sa
* Meadow — Undifferentiated meadow soils on wet alluvial and pond deposits.	Mw
* Muskeg — Undifferentiated bog (peat) soils on recent organic deposits.	Mk
* Meadow-Bog Complex — Mixed areas of meadow, shallow peat and bog soils.	M-B
* Dune Sand — Undifferentiated sands on aeolian dune deposits.	DS
* Undifferentiated Sands — Undifferentiated sand and loamy sand on alluvial-aeolian sand deposits.	US
* Eroded — Eroded soils of valley slopes and escarpments, chiefly thin (truncated) profiles.	Er
Smeaton Complex — Areas of Smeaton soils mixed with one or more of Kelsey, Garrick, Pine, Sylvania and Bodmin Associations.	SmX
Soils on mixed glacial till and lacustrine deposits. e.g.	P-K
Soils on mixed glacial till and glacio-fluvial deposits. e.g.	Wv-Bd
Soils on mixed glacial lacustrine and glacio-fluvial deposits. e.g.	Sb-Gb
Other soil complexes shown by soil symbols and color of dominant or most important soil association. e.g.	Wv-M-B



KEY MAP

SOIL SU

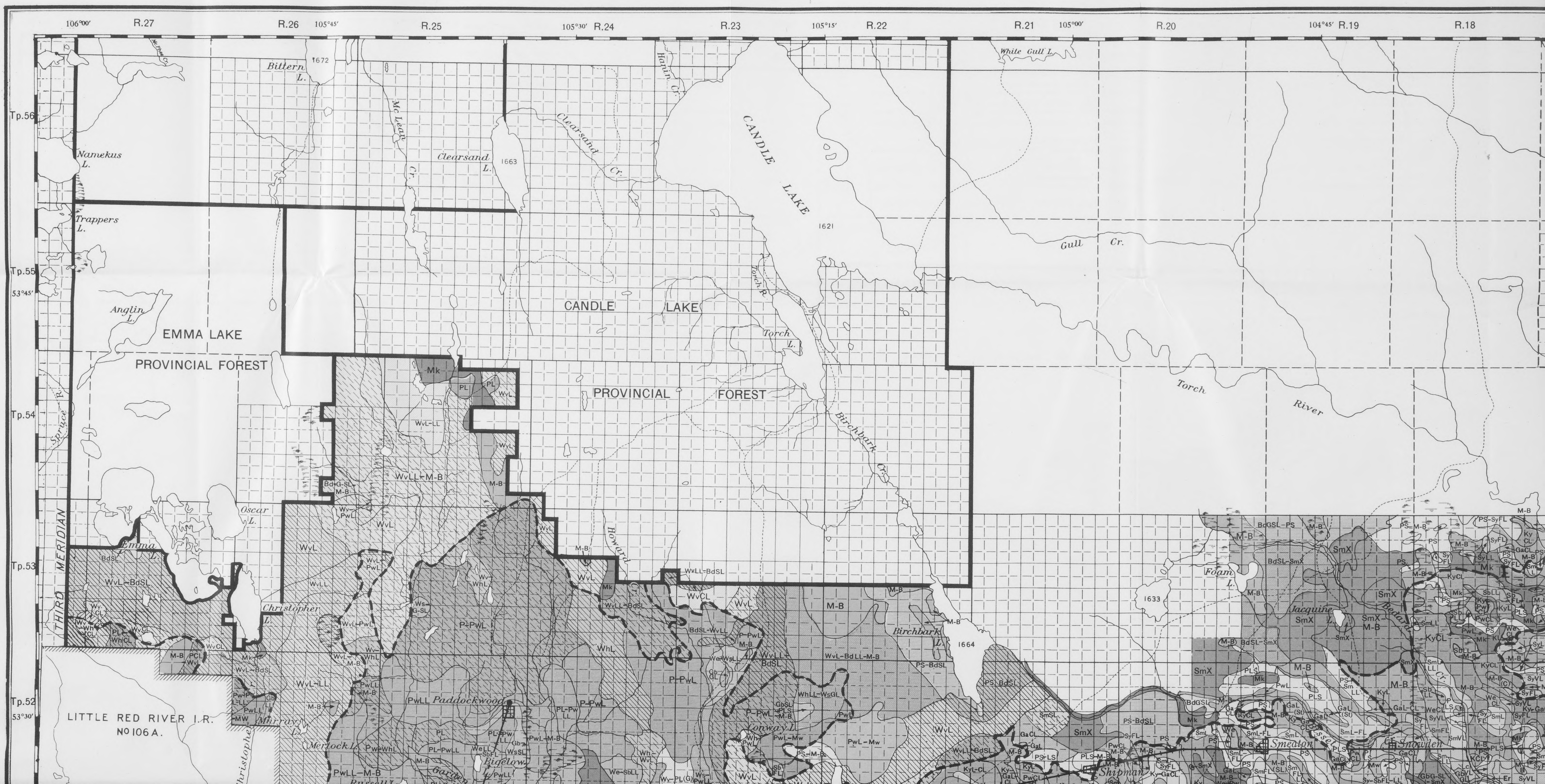
PRINCE ALBERT NORTH

PROVINCE OF

SOIL SURVEY

Scale 3

3 2 1 0



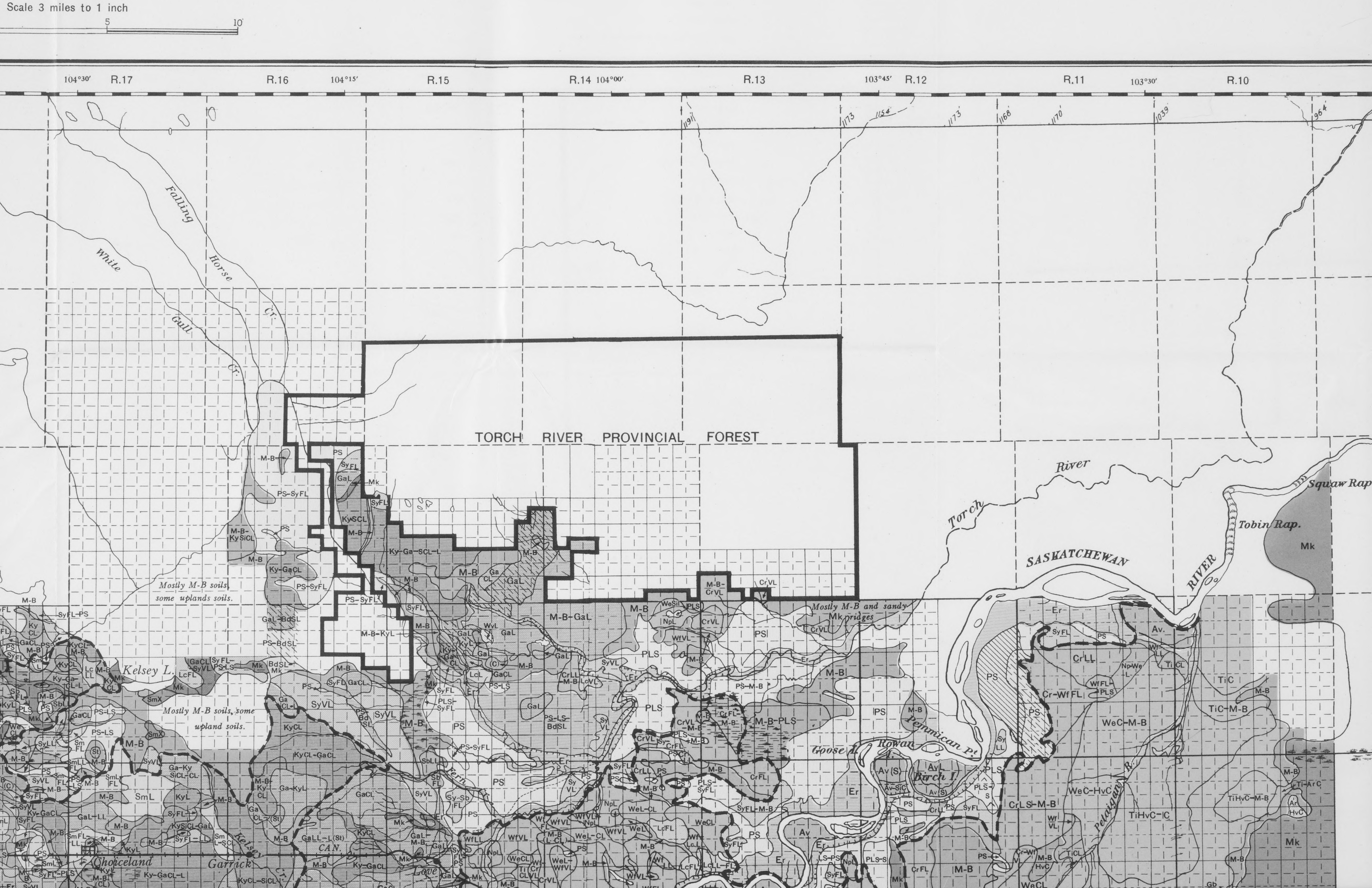
SURVEY OF

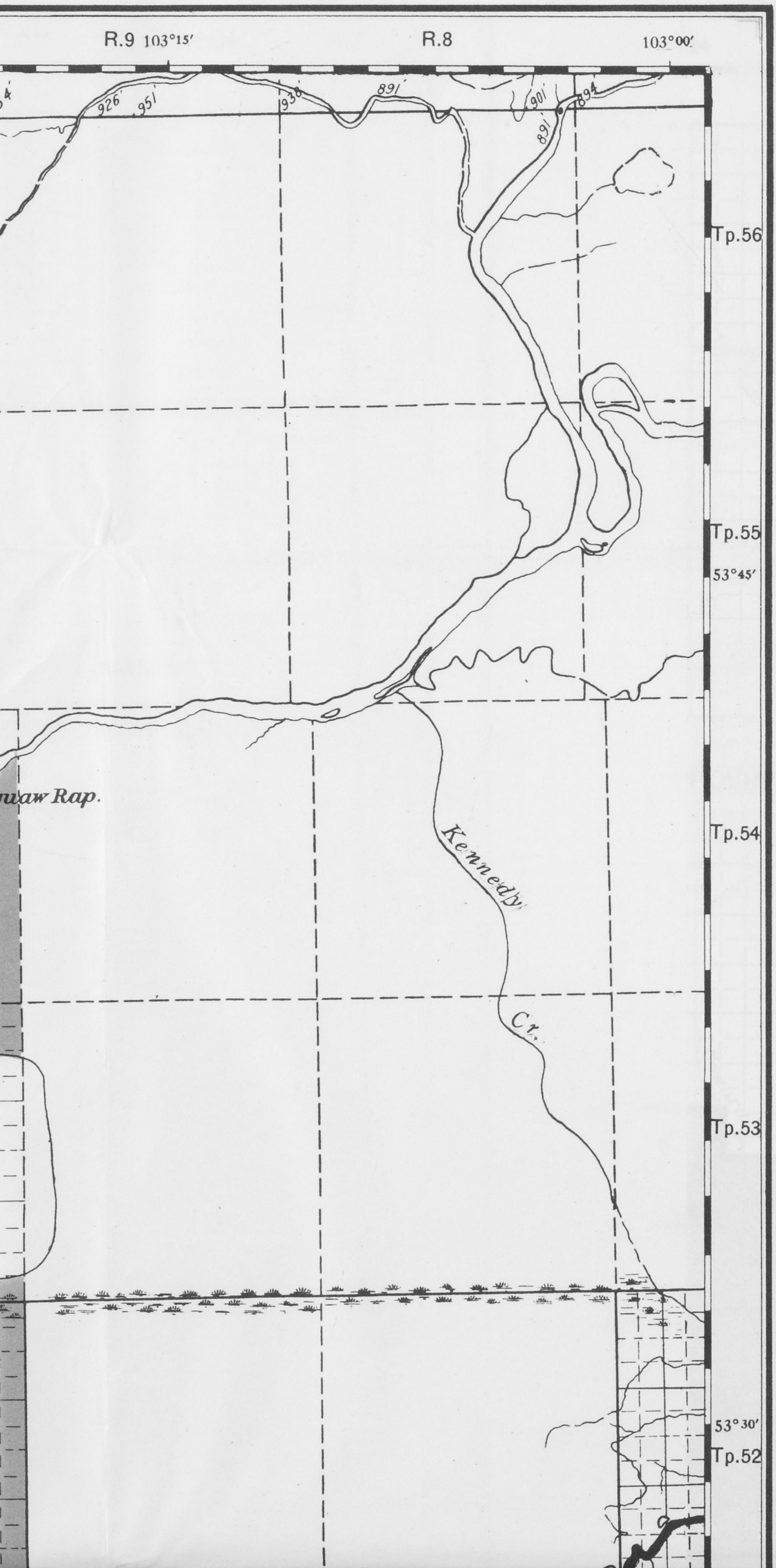
ORTH-CARROT RIVER SHEET

OF SASKATCHEWAN

SURVEY REPORT No. 13

Scale 3 miles to 1 inch




R.9
103°15′
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103°00′
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930
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894
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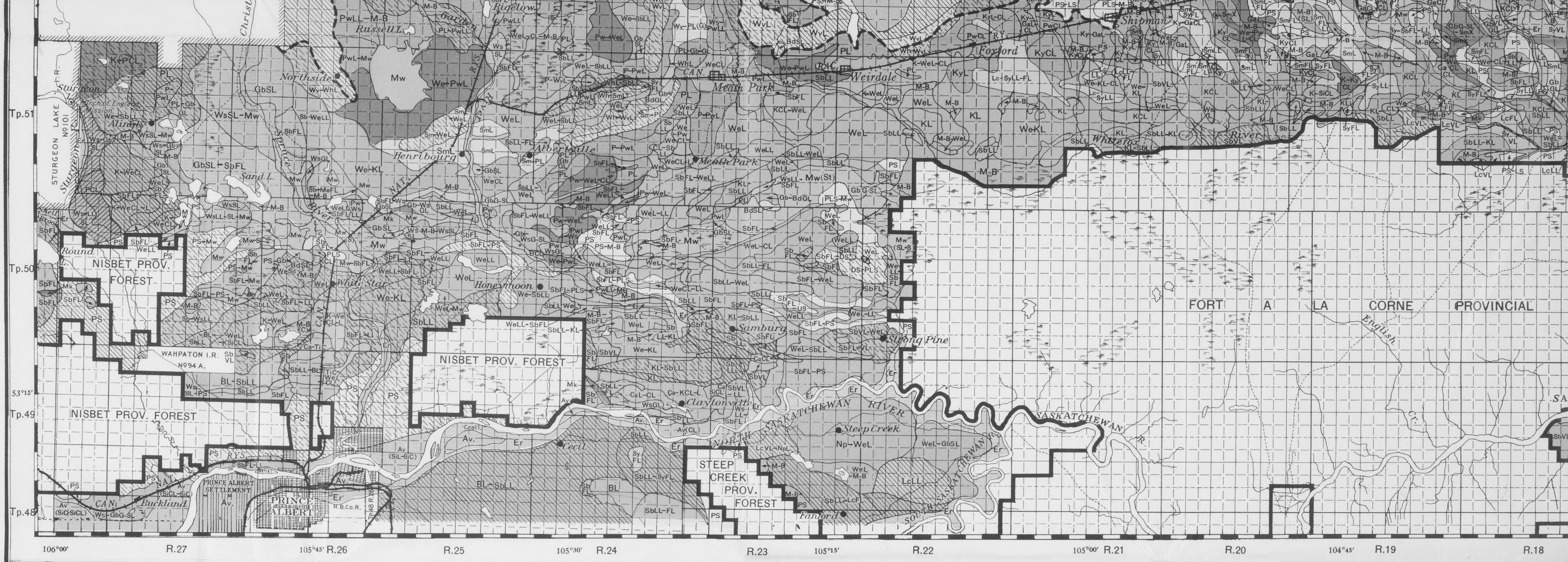
uwaw Rap.
Tp.54
Kennedy
Cr.
Tp.53
53°30′
Tp.52



Soil mapping, classification and topography, by the Saskatchewan Soil Survey, which is jointly supported by the University of Saskatchewan, the Provincial Department of Agriculture and the Dominion Experimental Farms Service.

LEGEN

REFERENCE

- Soil Zone Boundary
- Forest Boundary
- Indian Reserve
- Railway Line and Station
- Roads
- Town
- Country Post Office
- Elevation above sea level. 1712

DIAGRAM

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STONY AND GRAVELLY CLASSES

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Silty Loam	SiL
Loam	L
Light Loam	LL
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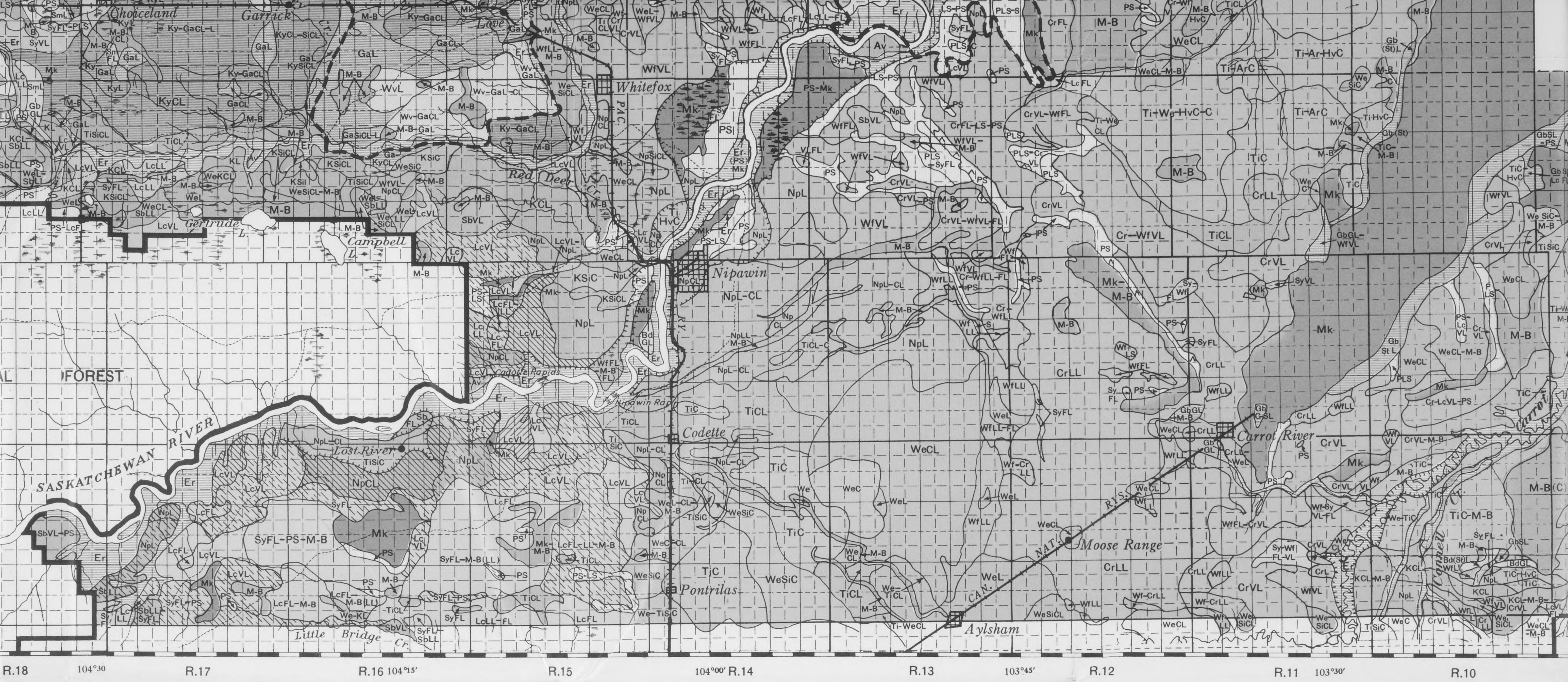

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Compiled, draw
by the Hydrogra

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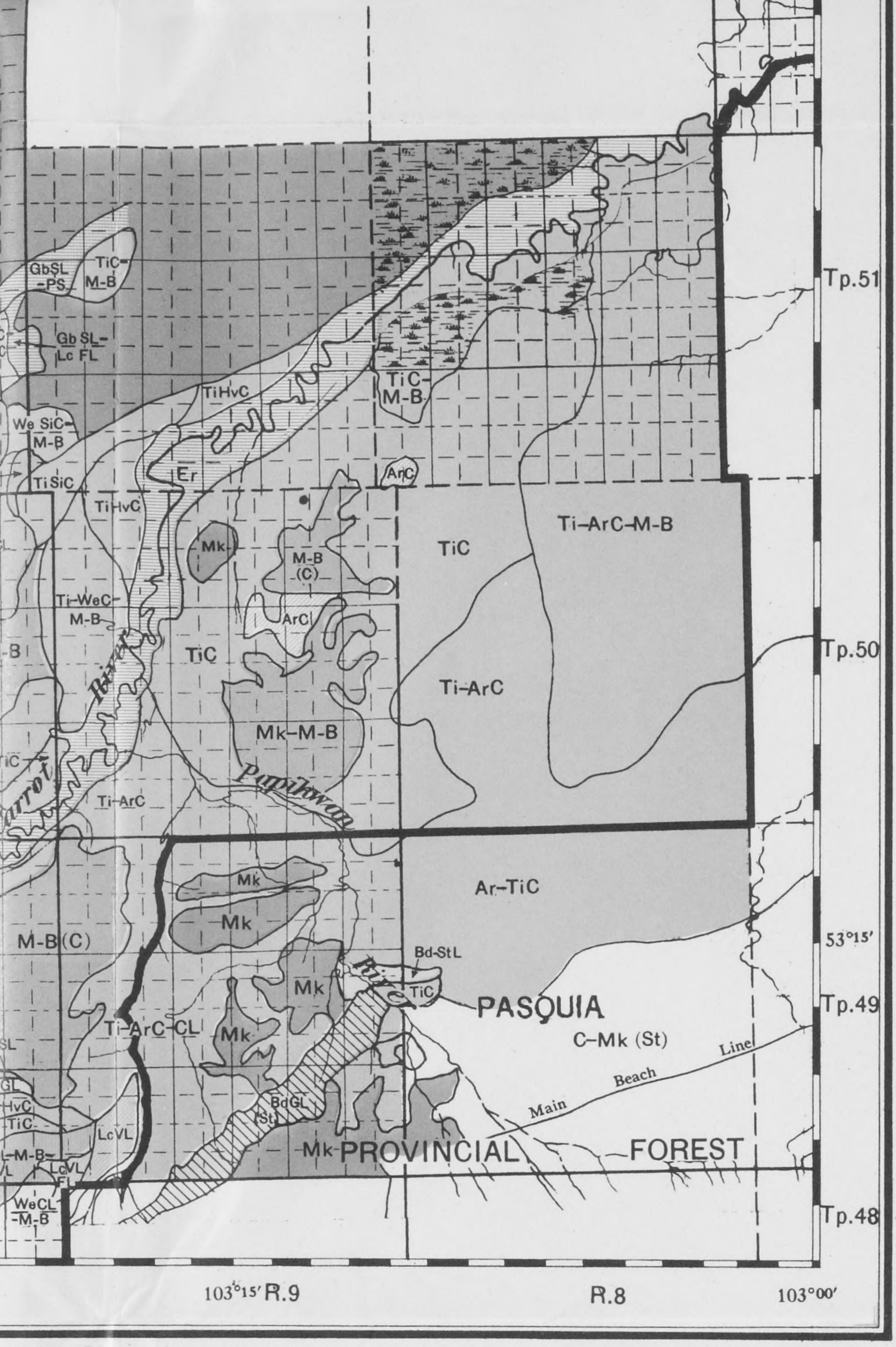

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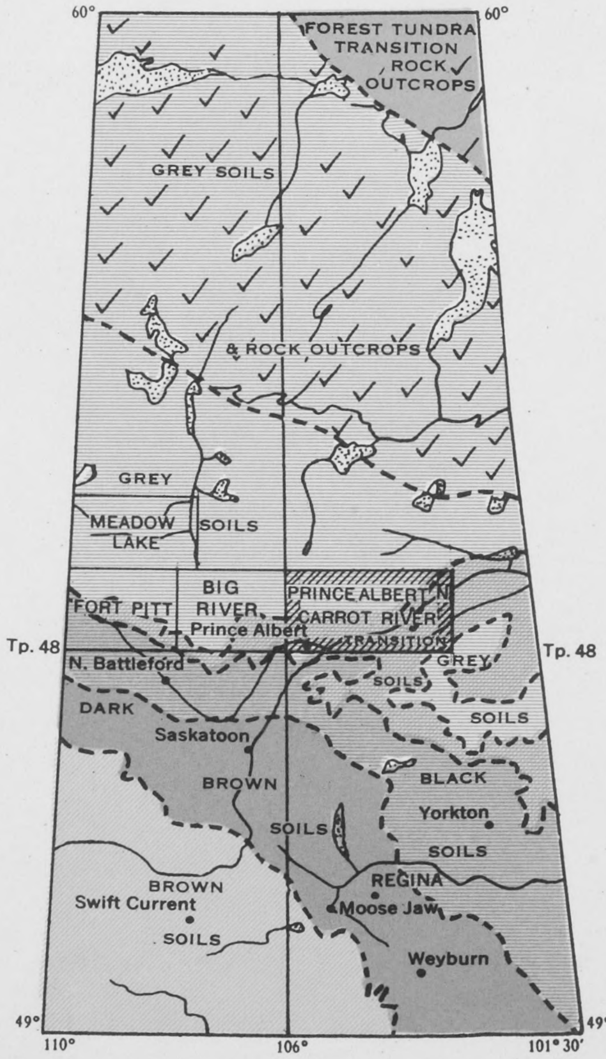

KEY MAP